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## Executive Editor

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# International Journal of Recent Technology and Engineering (IJRTE)

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## Contents

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# Enhanced Attendance Monitoring System using Biometric Fingerprint Recognition

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## ABSTRACT

*In this study, an enhanced attendance monitoring system using biometric fingerprint recognition in tracking and monitoring employees' attendances for Callang National High School, District 04, San Manuel, Isabela was introduced. For most organizations, handling people is a daunting job in which it is very important to maintain an accurate record of attendance. Taking and maintaining the attendance of employee manually on a regular basis is a big activity that requires time. For this reason an effective system was designed. The system was designed and developed primarily to improve the monitoring of employees attendances and leave management through the use of biometric technology. It records the data of the employees, handles leave management, tracks employee attendance and encourages participation through fingerprint recognition. The system is equipped with a dashboard monitoring system that can be viewed by school heads to track the list of employees, early birds (employees who arrived early), on-leave staff, on-official business and a statistical graph of the monthly attendance rate of employees. Moreover, the system provides an auto-generated DTR for employees which saved time compared to the manual process. The innovation greatly affects the improvement of employees' attendance through its automated attendance monitoring, leave management and report generated by the system. The impact of EAMS to the employees was identified through first quarter attendance report of SY 2028-2019 which served as a bases of comparison with the attendance rate of SY 2019-2020 when the system was implemented. The outcome shows that through the usage of the system, employees' attendance has improved.*

***Keywords: Biometric System, Attendance Monitoring System, Fingerprint Recognition, Employees Attendance***

## I. INTRODUCTION

Managing people is a difficult task for most of the organizations, and maintaining the attendance record is an important factor in people management. Manually taking the attendance and maintaining it for a long time adds to the difficulty of this task as well as wastes a lot of time [1]. Most of the attendance systems use paper based methods for taking and calculating attendance and this manual method requires paper sheets and a lot of stationery material [2]. To address these issues an automatic attendance system which automates the whole process of taking attendance should be implemented. Biometrics techniques are widely used in various areas like building security, forensic science, ATM, criminal identification and passport control [3]. The fingerprint recognition is widely used for many other purposes and it is widely popular technique [4]. The Fingerprint is the feature pattern of one finger or an impression of friction ridges found on inner surface of finger as shown in figure 1(a). Everyone in this world has his own fingerprint with the permanent uniqueness. A fingerprint is made up of ridges and furrows, which shows good similarities like parallelism and average width [5]. Fingerprint attendance system comprises at least one fingerprint scanner and a computer server. First templates of fingerprint related data are stored on the server, and similar templates are stored on the scanner. When a fingerprint is scanned, the fingerprint data is transmitted to the server, where a comparison is made. The server directs the scanner to display an indication whether or not a match was found [7].

The EAMS (Employees Attendance Monitoring System) utilizes a fingerprint biometric device where employees cast their daily attendances. It is capable of capturing attendances, records credit units, leave applications and official business records. It also facilitates automatic generation of DTR (Daily Time Record) and FORM 6 (Leave Form).The system is a great help in monitoring employees of CNHS because of its automation. Time consciousness will be practiced where every employee is expected to log/sign-in their daily attendance regularly which can be a key part of creating a school climate in which consistent teacher attendance is the norm.

## II. MATERIALS AND METHODOLOGY

### 2.1 Data Gathering

To determine the key features that will be added to the study the researchers asked the concerned staffs (ADAS and Teachers) or end users for features and add-ons to be included in the system. Moreover, the researchers also gathered the teachers attendance information based from the logbook of SY 2018-2019 and randomly selected 15 employees which served as a basis in identifying the impact of study in Improving the employees' attendance rate.

### 2.2 Prototyping

To develop a working interface of the program, prototyping and actual programming was done. The researchers used Visual Basic .Net as the front-end programming language, and MySQL as its back-end.

### 2.3 Alpha Testing

It was done by the researchers to test bugs and other technical errors that may occur during system development.

### 2.4 Beta Testing

It was done to test and deploy the system with the users (Teacher and Non-Teaching Staff and the Proponent of the Study).

### 2.5 System Implementation

This was done to determine the effectiveness of the developed program. The following procedures cover the implementation The employees' registration was done where employees' information and fingerprint templates are stored.

#### 2.5.1. Employees Registration.

The employees' registration was done where employees' information and fingerprint templates are captured which will be the basis of their attendance casting.

#### 2.5.2. Casting of Attendances.

Employees used their registered fingerprint to cast their attendances. Employees' attendances are reflected directly to their DTRs.

### 2.5.3. Leave Management.

Employees leave credits and leave applications are stored as basis of leave w/ pay and leave w/o pay.

### 2.5.4. Printing and DTR (Daily Time Record).

This was done to provide the employees their auto-generated DTR where their logs and leave applications are reflected.

**Figure 1: Employees Registration**

**Figure 2: Casting Employees attendance**

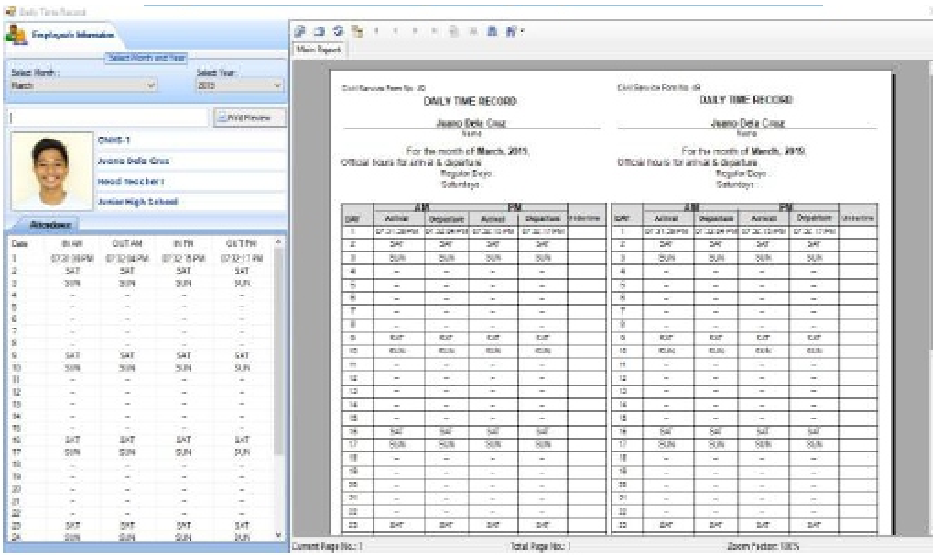


**Figure 3: Printing of DTR (Daily Time Record)**

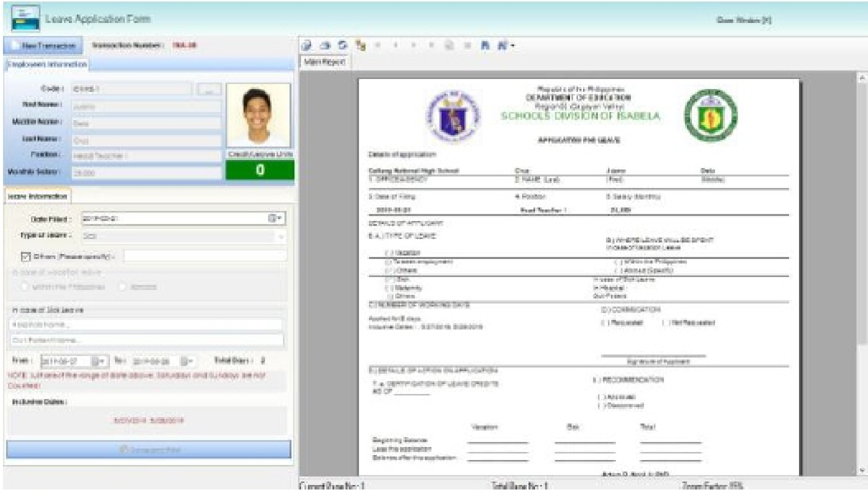


**Figure 4: Leave Application**

### 2.6 System Evaluation

This was done to determine the extent of impact of the system in improving the attendance rate of the employees. The researcher gathered the first quarter attendance report of SY 2028-2019 and randomly selected 15 employees which served as a bases of comparison with the attendance of SY 2019-2020 when the system was implemented. The average rate of late attendance from the attendance report of SY 2018-2019 was compared to the average rate of attendance generated by the system.

## III. RESULTS AND DISCUSSION

### 3.1 Comparative Analysis

The implementation of the developed program (Employees Attendance Monitoring System) automatically facilitates employees' registration, generation of employees' DTR and leave form and monitoring of employees' attendance. The employees' have less time consumption in preparing their attendances through the auto-generated DTR's/ Moreover, awareness among the employees attendance are assured through its real-time dashboard monitoring which can be viewed by the school-head.

| LOGBOOK DATA - FIRST QUARTER SY 2018-2019 | | | | | | |
|---|---|---|---|---|---|---|
| EMPLOYEE NO | NUMBER OF LATE | | | | | |
| | JUNE | % Late | JULY | % Late | AUGUST | % Late |
| 1 | 1 | 3.33 | 3 | 10 | 3 | 10 |
| 2 | 0 | 0 | 4 | 13.33 | 10 | 33.33 |
| 3 | 4 | 13.33 | 1 | 3.33 | 8 | 26.67 |
| 4 | 4 | 13.33 | 6 | 20 | 14 | 46.67 |
| 5 | 10 | 33.33 | 11 | 36.67 | 10 | 33.33 |
| 6 | 11 | 36.67 | 9 | 30 | 17 | 56.67 |
| 7 | 0 | 0 | 1 | 3.33 | 4 | 13.33 |
| 8 | 0 | 0 | 7 | 23.33 | 0 | 0 |
| 9 | 2 | 6.67 | 8 | 26.67 | 13 | 43.33 |
| 10 | 0 | 0 | 3 | 10 | 4 | 13.33 |
| 11 | 0 | 0 | 10 | 33.33 | 7 | 23.33 |
| 12 | 2 | 6.67 | 2 | 6.67 | 3 | 10 |
| 13 | 1 | 3.33 | 4 | 13.33 | 17 | 56.67 |
| 14 | 10 | 33.33 | 16 | 53.33 | 21 | 70 |
| 15 | 5 | 16.67 | 8 | 26.67 | 18 | 60 |
| **TOTAL** | **50** | **166.66** | **93** | **309.99** | **149** | **496.66** |
| MONTHLY PERCENTAGE LATE | 11.11 | | 20.67 | | 33.11 | |
| AVERAGE LATE ATTENDANCE | | | | | 21.63 | |

**Table. 1. Employees' average late attendance during the first quarter of the SY 2018-2019.**

The table 1 shows the computed late attendance percentage of employees for the first quarter of SY 2019-2020.

| EAMS ATTENDANCE REPORT – FIRST QUARTER SY 2019-2020 | | | | | | |
|---|---|---|---|---|---|---|
| NO | NUMBER OF TARDINESS | | | | | |
| | JUNE | % Late | JULY | % Late | AUGUST | % Late |
| 1 | 4 | 13.33 | 1 | 3.33 | 3 | 10 |
| 2 | 0 | 0 | 4 | 13.33 | 3 | 10 |
| 3 | 4 | 13.33 | 1 | 3.33 | 8 | 26.67 |
| 4 | 2 | 6.67 | 1 | 3.33 | 5 | 16.67 |
| 5 | 5 | 16.67 | 4 | 13.33 | 5 | 16.67 |
| 6 | 3 | 10 | 3 | 10 | 4 | 13.33 |
| 7 | 0 | 0 | 0 | 0 | 2 | 6.67 |
| 8 | 0 | 0 | 7 | 23.33 | 0 | 0 |
| 9 | 2 | 6.67 | 5 | 16.67 | 5 | 16.67 |
| 10 | 0 | 0 | 3 | 10 | 4 | 13.33 |
| 11 | 0 | 0 | 5 | 16.67 | 5 | 16.67 |
| 12 | 2 | 6.67 | 2 | 6.67 | 3 | 10 |
| 13 | 3 | 10 | 2 | 6.67 | 5 | 16.67 |
| 14 | 4 | 13.33 | 3 | 10 | 5 | 16.67 |
| 15 | 2 | 6.67 | 1 | 3.33 | 6 | 20 |
| **TOTAL** | **31** | **103.34** | **42** | **139.99** | **63** | **210.02** |
| **MONTHLY PERCENTAGE LATE** | 6.89 | | 9.33 | | 14 | |
| **AVERAGE LATE ATTENDANCE** | | | | | 10.07 | |

**Table. 2. Employees' average late attendance during the first quarter of the SY 2019-2020.**

The table 2 shows the computed late attendance percentage of employees for the first quarter of SY 2019-2020

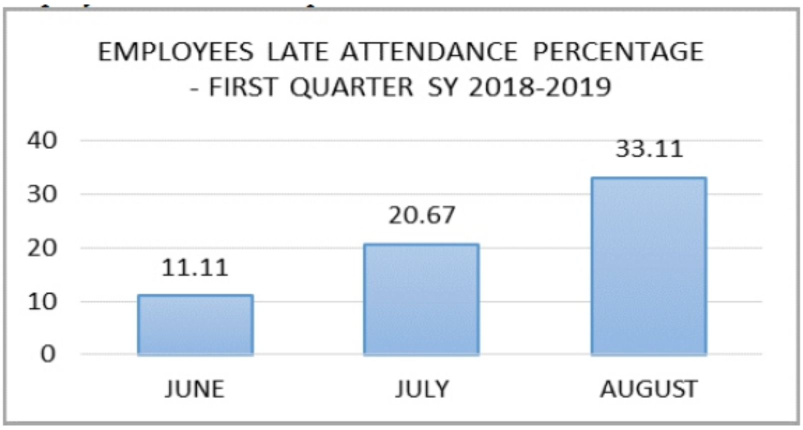


**Fig. 6. Employees' average late attendance during the first quarter of the SY 2018-2019.**

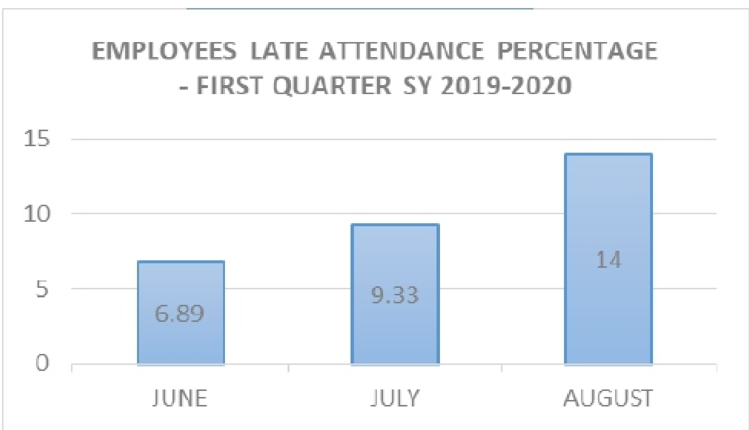


**Fig. 6. Employees' average late attendance during the first quarter of the SY 2019-2020.**

The graph in the figure 6 shows Employees' late attendance record percentage during the first quarter of the SY 2019-2020.

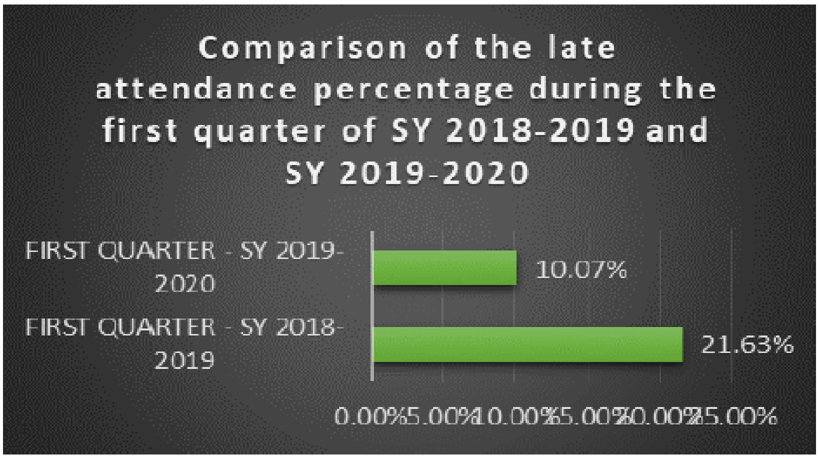


**Fig. 7. Comparison of the late attendance percentage during the first quarter of SY 2018-2019 and SY 2019-2020.**

The graph in the figure 3 shows the comparison of employees' attendance during the first quarter period of both SY 2018-2019 and SY 2019-2020. The result shows that there was an improvement in employees' attendances through the use of the developed program. Employees' late percentage was decreased by 11.56 % which signifies that the program can be considered as one of the effective tools for the improvement of employees' attendance. Meanwhile, there were still extraneous that affect the on-time attendance of employees, it is highly recommended that aside from the automated monitoring system, The school head should also consider issues regarding transportation and the distance between the employees residence and the school.

### 3.2 Development of the Program Interface

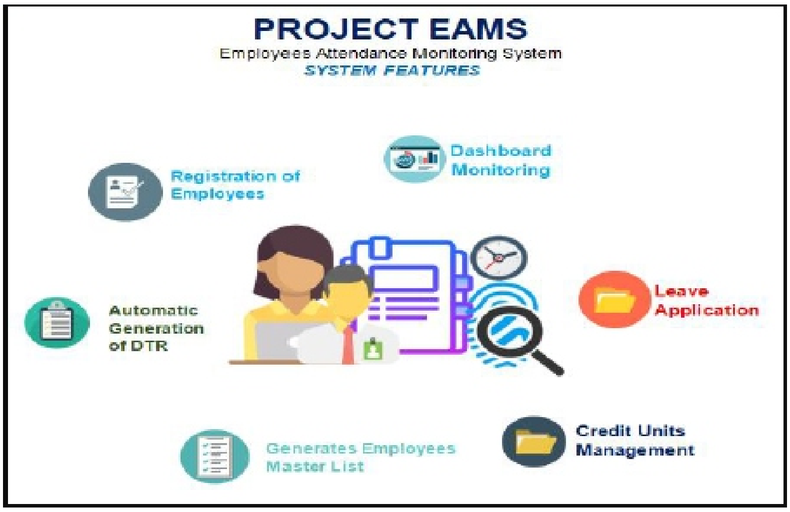


**Fig. 8. The Framework**


**Fig. 9. Employees Registration Window**

The register employees' information allows the user to register basic information of employees together with its 4 fingerprint samples to be used to cast his/her daily attendance.

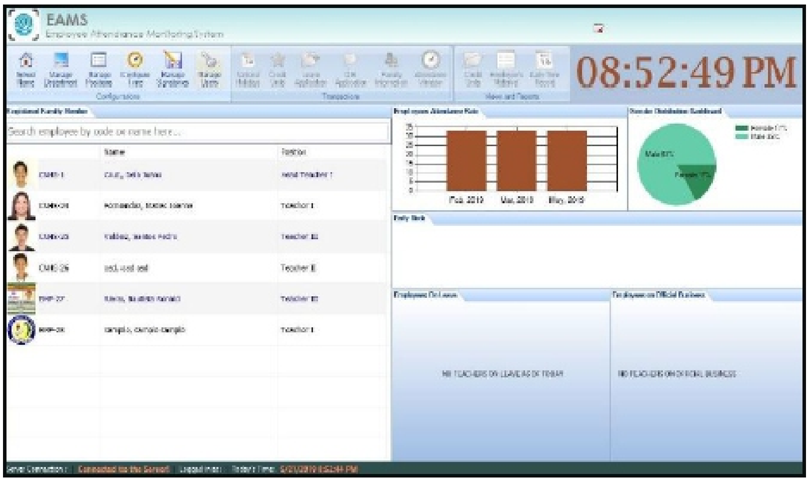


**Fig. 10. Dashboard Monitoring Window**

The main window allows the user to view attendance statistical dashboard together with the pie graph distribution of male and female teachers. It also allows the user to view early birds / employees who arrives early in school and a monitoring board for employees on leave and on official business.

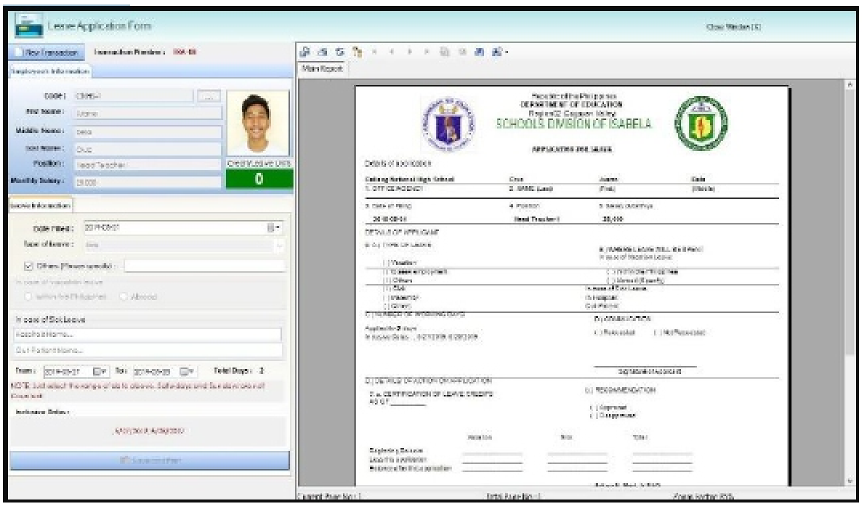


**Fig. 11. Leave Application Window**

The leave application form allows an employee to electronically apply for his / her leave. The user will just search an employee and identify his leave type. Once the employee clicks save and print transaction button, the system provides a pre-formatted FORM 6 or leave form that can be printed and downloaded.

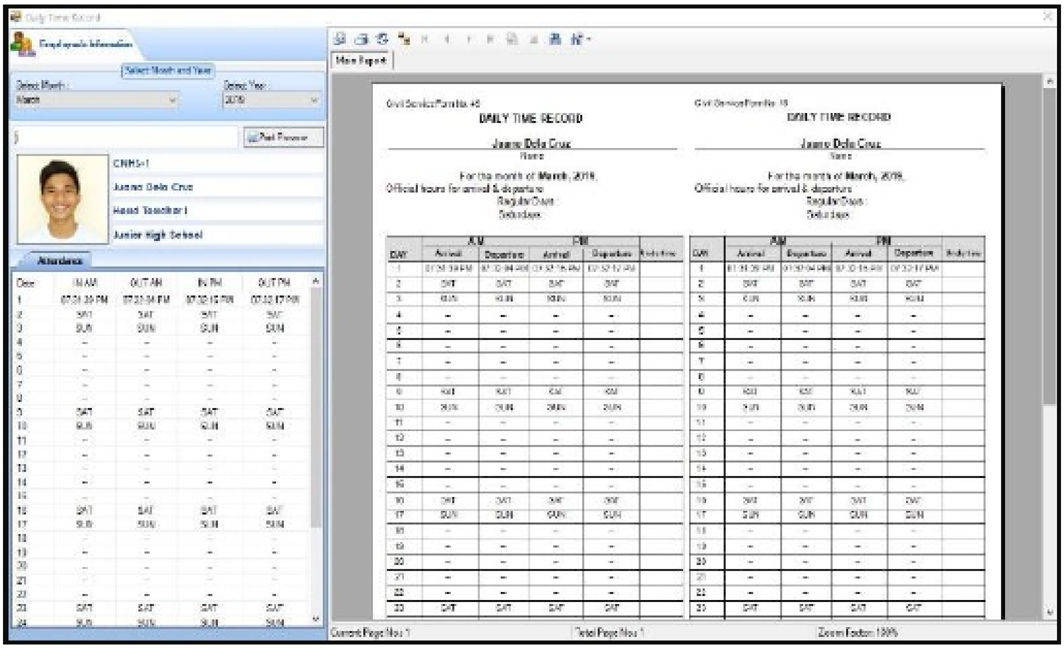


**Fig. 12. Individual Monthly Attendance Window / DTR Window**

The DTR window allows the user to print employees DTR by selecting the month, year and the employee. A DTR containing logs of employees will be displayed and can be printed.

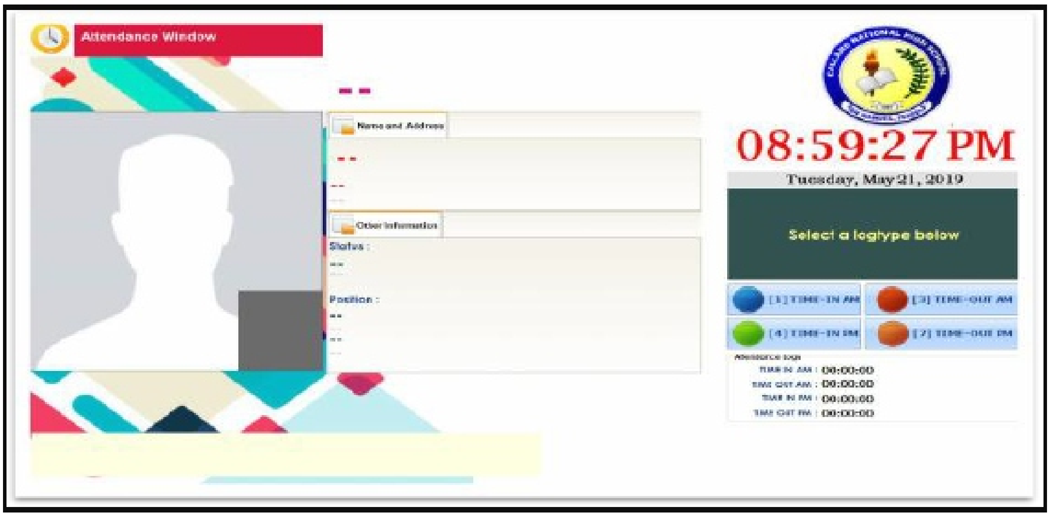


**Fig. 13. Attendance Window**

The attendance window allows employees to cast attendances. The employee will choose first on what attendance log will he be casting. After selecting the log type, the employee can now plot his registered fingerprint to the biometric device for recognition and recording of attendance logs.

## IV. CONCLUSION

It can be concluded that the enhanced attendance monitoring system using fingerprint biometric recognition is effective to replace a manual system that is inefficient. Results have shown that this system can be applied in academic institutions to produce better results in attendance management. This system would save time, reduce the amount of work that the administration needs to do and replace stationery content with electronic equipment. However, a system with anticipated performance has still some rooms for improvement.

## ACKNOWLEDGMENT

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## AUTHORS PROFILE

**Ronald B. Rivera,** finished his MIT degree at Isabela State University – Cauayan campus in 2017. He obtained his Bachelor of Science in Information Technology at the Isabela State University – Echague Campus, San Fabian Echague, Isabela. He started his teaching profession at the La Salette of Cabatuan, Cabatuan Isabela as a computer teacher, he has been a Basic Education Curriculum Teacher for 8 years, has been designated as one of the brigade innovators in the SY 2019-2020 at Callang National High School. He has been tapped by various agencies to perform job relevant to his field of specialization. At present, he is a college instructor at Isabela State University – Angadanan Campus.

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# Modelling, Simulation and Control of Robotic Hand using Virtual Prototyping Technology

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[2]UG student, Mechanical engineering department, NIT Durgapur, Durgapur, west Bengal, India.

## ABSTRACT

*Hand is one of the most important body parts of a human being that exhibits extremely complex motional behaviors. So, accurate design of a prosthetic hand with precise motion has been a very challenging job for researchers over a few decades. Moreover, selection of materials, actuators, sensors, etc. becomes tedious which prior knowledge of the probable outcomes of a particular design. This paper presents an organized procedure to design and solve the kinematics, dynamics and trajectory control problem of a robotic hand. Denavit- Hartenberg method was used for the kinematic analyses and Lagrange-Euler formulation applied on basic rotational mechanics was used for the dynamic analyses of the robotic hand. To reduce difficulty, three degrees of freedom has been assigned to each finger. MATLAB codes were written to develop the mathematical model and carry out the theoretical calculations. The results so obtained were verified with the actual simulation results of the design which were obtained from ADAMS and hence validating the design. Finally, a PID controller was implemented using ADAMS-MATLAB CO-SIMULATATION technique, for controlling the hand, so as to achieve the desired motion. By the virtue of the results obtained the choice of materials, actuators, sensors, etc. becomes easier in case of the physical prototype which is the primal essence of virtual prototyping.*

***Index Terms: Kinematics, Dynamics, Virtual Prototyping technology, PID Controller, Co- Simulation.***

## I. INTRODUCTION

In the field of robotics, hand design has been one of the most interesting topics for researchers over a past few years for its versatile applications such as shortening the metal component [1], fruit picking [2], drawing, welding, bomb defusing [3] etc. Its diversity is extended further in the form of exoskeletons that provides the base of rehabilitation robotics [4]. These robots are designed according to the function and shape of the human body and the user will be able to control the robotic limbs. These robotic limbs may be active or passive depending on the user application. But still the exact movement of the human hand is still unsolved because of its complicated structure. So, without knowledge of its basic anatomy, the design of the hand model is quite challenging. The structure of the hand includes bones and joints, ligaments and tendons, muscles, nerves, circulatory system, and skin; however, this paper only focused in area of bones and joints. The basic parts of the human hand are; wrist, palm and five fingers (thumb, index finger, middle finger, ring finger, and little finger) [5], that are shown in Fig 1. Actually, the human hand has total twenty-seven bones including wrist bones [6]. The arrangement of these bones is different at different positions of hand viz. eight carpal bones are arranged in a wrist but in two set of rows, each set carries four bones, palms have total five long metacarpal bones that connects every finger individually and the remaining fourteen phalangeal bones are positioned at four fingers and the thumb [5]. The details about bones and joints of human hand has been shown in Fig 1 [7]. Joints not only make a bridge among the different bones but also give the motion to the fingers. There are five types of joints present in the hand, from wrist to the end of the fingers which are CMC, MCP, IP, PIP and DIP that has shown in Fig 1 [7]. CMC joint connects carpal bones and metacarpal bones and MCP joint connects metacarpal bones and phalanges of every finger. There are some differences among DIP, PIP and IP joints. The IP joint is present only in thumb in between its proximal and distal phalangeal whereas PIP and DIP joints connect the proximal with the middle phalangeal and the middle with the distal phalangeal respectively of the rest of the fingers [5], [8].

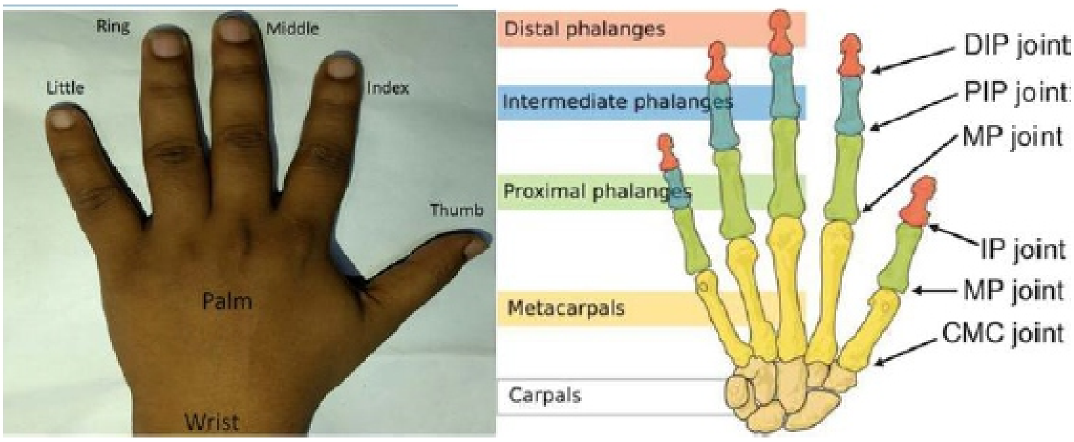


**Fig 1: The human hand and the bones and joints human hand [7].**

Based on the joints and bones, the human hand motion is divided into two categories the flexion /extension and abduction / adduction. Flexion/extension means rotation of finger towards and away from the palm but it occurs in a plane perpendicular to the palm and abduction / adduction means spreading and closing of the fingers occurring in a plane parallel to the palm [9]. Depending on the type of motion different angular displacements are fixed for every joint in the finger. In order to achieve all these ranges of motion and make the robotic hand more accurate, different researchers assign different degrees of freedom to their model. Degrees of freedom decide the minimum number of independent parameters required to describe a system exactly [10]. Higher degrees of freedom complexifies the design extremely. So, careful choice of degrees of freedom stands important for a simple and yet elegant manipulator design. The design of a simple manipulator in real life by considering all the above standards requires fixation of a lot of parameters like mechanism, material, actuator, sensors etc. Development of the device by trial-and-error method is very much time consuming as well as uneconomical.

To overcome this inadequacy, this paper gives an idea about virtual prototyping (VP) technology that is quite cost effective and time saving also. Virtual prototyping (VP) technology means execution of the motion algorithms on a virtual model and refining its performance prior to development of a physical prototype [11]. In this paper the kinematics, dynamics and control problem of the hand has been solved based on VP technology. This paper mainly focuses on three distinguish areas namely kinematics, dynamics and control. The kinematics has got two parts a) Forward kinematics, b) Inverse kinematics. Forward kinematics deals with the determination of the position of the end effector from the given joint angle motion [10]. The position obtained from the forward kinematics has been mapped to the global coordinate system of ADAMS software which is one of another difficult issue for every simulation-based analysis [5]. In inverse kinematics, the joint angles are calculated from given position and orientation of end effector by using simple algebraic method. The velocity and acceleration analysis has also been carried out for the joints as well as the end effectors. The dynamic analysis of the hand is sub-dived into 3 parts a) motion dynamic analysis without considering the static force b) static force analysis and c) motion dynamic analysis along with the static force [12]. In motion dynamic analysis without considering the static force, the dynamic equations have been solved by following the Lagrange-Euler method. Most of the papers follow generalized dynamic equation to solve dynamics problems [5], on the other hand this article goes through the basic rotational mechanics in order to carry out the dynamic analyses [5]. This method is more powerful in order to get a clear insight of the matter. In static force analysis, a simple relationship has been made between the joint torque vector for each joint ( $\tau_{si}$ )and end effector load (F) vector [12]. A continuous static force analysis curve has been plotted in MATLAB which is another important aspect of this paper. Since all the joints need to be fixed at every position, continuous curve of static force could not be obtained in ADAMS. Finally, the complete dynamic solution is obtained by combining both motion dynamics and static force analysis. After that, a simple PID controller was developed using the ADAMS-MATLAB co-simulation strategy which is another powerful aspect of this analysis [13], [14], [15].

## II. DESIGN OF THE HAND

It is needless to mention that the design is inspired from human hand with little alterations to the degrees of freedom. The thumb has got three degrees of freedom with joint axis of the first joint being perpendicular to the other two. The rest of the fingers also have three degrees of freedom but all the joint axes are parallel in this case. CATIA was used for the design purpose. The design is shown below Figure: 2.1

**Fig 2: Catia model**

This design was used for the detailed analyses the steps of which are listed below:

i. The hand was designed as stated above.
ii. MATLAB codes were written to carry out the theoretical analysis.
iii. The design was imported in MSC ADAMS.
iv. Simulation of the model was carried out in ADAMS by giving joint motions.
v. The results of simulation (ADAMS) and the theoretical calculations (MATLAB) were compared so as to validate the experiment.

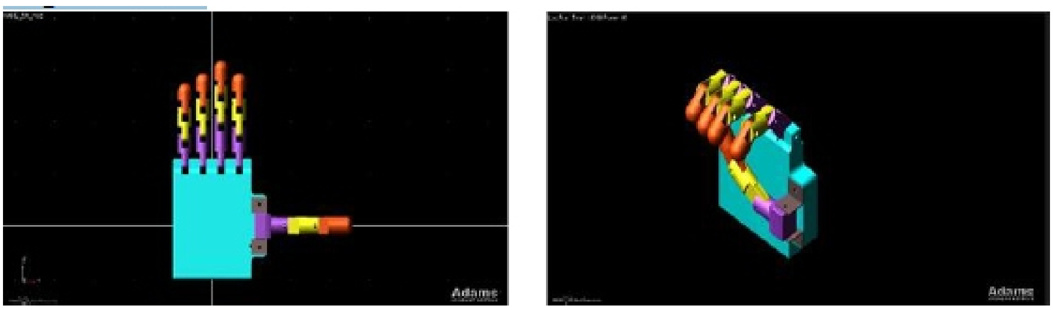


**Fig 3: Hand model imported to ADAMS: (a) Before simulation (b) After simulation**

The detailed theoretical analyses have been carried in the followed sections.

## III. KINEMATICS ANALYSIS OF THE HAND

Robot kinematics deals with the study of motion of the robot without taking into account the cause of motion. In this section the kinematic analysis of each finger has been carried out in detail. Robot kinematics has got two phases viz. (1) Forward Kinematics and (2) Inverse Kinematics( $\tau_{si}$ ): former deals with determining the position and orientation of end effector with the known joint variables whereas the later deals with determination of the joint variables while the position and orientation of the end effector is known [5]. However, the analysis in this section does not merely hover around position analysis only. The velocity and acceleration analysis of the joints and the end effector has also been carried out in the subsequent sections.

### A. Kinematics of thumb

The DH Parameter of the thumb is shown below:

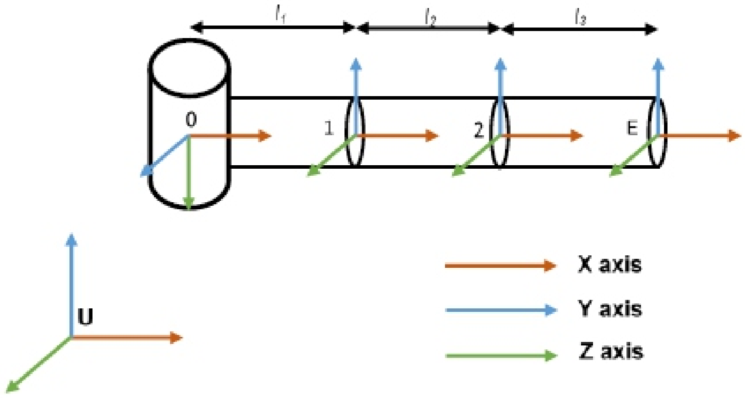


**Fig 4: Denavit- Hartenberg parameter model of thumb**

**Table 1: Denavit- Hartenbag parameter of Thumb**

| Frame | $\theta_i$ (degree) | $d_i$ (mm) | $\alpha_i$ (degree) | $a_i$ (mm) |
|---|---|---|---|---|
| 0-1 | $\theta_1$ | 0 | -90 | $l_1$= 32 |
| 1-2 | $\theta_2$ | 0 | 0 | $l_2$= 39 |
| 2-E | $\theta_3$ | 0 | 0 | $l_3$= 47 |

**Forward Kinematics of thumb**

Each joint has been assigned a cubic trajectory: $\theta_i = a_0 + a_1 t + a_2 t^2 + a_3 t^3$ .The range of motions of each joint has been presented below:

**Table 2: Range of motion of each joint of thumb**

| $\theta_i$ | $\theta_i$ (deg) | $\theta_f$ (deg) | $\dot{\theta}_i$ (deg/s) | $\dot{\theta}_f$ (deg/s) | $t_i$ (s) | $t_f$ (s) |
|---|---|---|---|---|---|---|
| $\theta_1 = 540t^2 - 360t^3$ | 0 | 180 | 0 | 0 | 0 | 1 |
| $\theta_2 = 72t^2 - 48t^3$ | 0 | 24 | 0 | 0 | 0 | 1 |
| $\theta_3 = 72t^2 - 48t^3$ | 0 | 24 | 0 | 0 | 0 | 1 |

The position and orientation of a frame with respect to its previous frame is given by the following homogeneous transformation matrix:

$$ {}^{i-1}_{i}T = \begin{bmatrix} C\theta_i & -S\theta_i C\alpha_i & S\theta_i S\alpha_i & a_i C\theta_i \\ S\theta_i & C\theta_i C\alpha_i & -C\theta_i S\alpha_i & a_i S\theta_i \\ 0 & S\alpha_i & C\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

Where $C\theta_i = \cos\theta_i$ , $S\theta_i = \sin\theta_i$ , $C\alpha_i = \cos\alpha_i$ $S\alpha_i = \sin\alpha_i$

$$ {}^{0}_{E}T = {}^{0}_{1}T \times {}^{1}_{2}T \times {}^{2}_{E}T \qquad (1) $$

Equation (1) represents the homogenous transformation matrix of end effector frame with respect to the base coordinate frame.

$$ {}^{0}_{E}T = \begin{bmatrix} C\theta_1 C(\theta_2+\theta_3) & -C\theta_1 S(\theta_2+\theta_3) & -S\theta_1 & l_1 C\theta_1 + l_2 C\theta_1 C\theta_2 + l_3 C\theta_1 C(\theta_2+\theta_3) \\ S\theta_1 C(\theta_2+\theta_3) & -S\theta_1 S(\theta_2+\theta_3) & C\theta_1 & l_1 S\theta_1 + l_2 S\theta_1 C\theta_2 + l_3 S\theta_1 C(\theta_2+\theta_3) \\ -S(\theta_2+\theta_3) & -C(\theta_2+\theta_3) & 0 & -l_2 S\theta_2 - l_3 S(\theta_2+\theta_3) \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

Where, $\theta_{23} = \theta_2 + \theta_3$ and $\theta_{123} = \theta_1 + \theta_2 + \theta_3$

However, the universal reference frame is not same as that of the first joint frame. So, a series of transformations has been carried out in order to get the position and orientation with respect to the universal reference frame. The transformations are shown below:

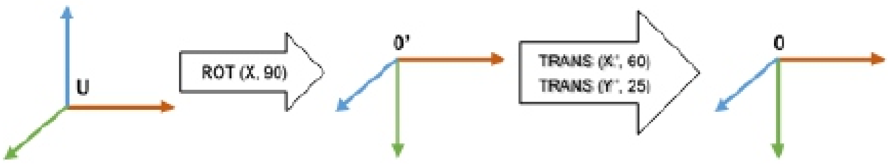


**Fig 5: Position mapping model of thumb**

The mapping matrix is given by:

$$ H = Rot(X, 90^0) \times Trans(X', 60) \times Trans(Y', 25) \quad (2) $$

$$ H = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & C90^0 & -S90^0 & 0 \\ 0 & S90^0 & C90^0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 60 \\ 0 & 1 & 0 & 25 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ H = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 60 \\ 0 & 1 & 0 & 25 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$H = \begin{bmatrix} 1 & 0 & 0 & 60 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 25 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The final position and orientation matrix with respect to the universal frame is given by:

$$^{U}_{E}T = H \times {}^{0}_{E}T \qquad (3)$$

$$^{U}_{E}T =$$

$$\begin{bmatrix} C\theta_1 C\theta_{23} & -C\theta_1 S\theta_{23} & -S\theta_1 & l_1C\theta_1 + l_2C\theta_1C\theta_2 + l_3C\theta_1C\theta_2C\theta_3 - l_3C\theta_1S\theta_2S\theta_3 + 60 \\ S\theta_{23} & C\theta_{23} & 0 & l_2S\theta_2 + l_3S\theta_{23} \\ S\theta_1C\theta_{23} & -S\theta_1S\theta_{23} & C\theta_1 & l_1S\theta_1 + l_2S\theta_1C\theta_2 + l_3S\theta_1C\theta_2C\theta_3 - l_3S\theta_1S\theta_2S\theta_3 + 25 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

So, the position of the end effector is given as:

$$X = l_1C\theta_1 + l_2C\theta_1C\theta_2 + l_3C\theta_1C\theta_2C\theta_3 - l_3C\theta_1S\theta_2S\theta_3 + 60 \quad (4)$$

$$Y = l_2S\theta_2 + l_3S\theta_{23} \quad (5)$$

$$Z = l_1S\theta_1 + l_2S\theta_1C\theta_2 + l_3S\theta_1C\theta_2C\theta_3 - l_3S\theta_1S\theta_2S\theta_3 + 25 \quad (6)$$

**Inverse kinematics of thumb**

In this section, joint variables are determined with the known position and orientation matrix of the end effector. However, in this case, the matrix will be with respect to the first joint frame rather than the universal frame ($^{0}_{E}T$).

Let assume,

$$\begin{bmatrix} C\theta_1C(\theta_2+\theta_3) & -C\theta_1S(\theta_2+\theta_3) & -S\theta_1 & l_1C\theta_1 + l_2C\theta_1C\theta_2 + l_3C\theta_1C(\theta_2+\theta_3) \\ S\theta_1C(\theta_2+\theta_3) & -S\theta_1S(\theta_2+\theta_3) & C\theta_1 & l_1S\theta_1 + l_2S\theta_1C\theta_2 + l_3S\theta_1C(\theta_2+\theta_3) \\ -S(\theta_2+\theta_3) & -C(\theta_2+\theta_3) & 0 & -l_2S\theta_2 - l_3S(\theta_2+\theta_3) \\ 0 & 0 & 0 & 1 \end{bmatrix} =$$

$$\begin{bmatrix} r_{11} & r_{12} & r_{13} & p_x \\ r_{21} & r_{22} & r_{23} & p_y \\ r_{31} & r_{32} & r_{33} & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Multiplying both sides by $^{0}_{1}T^{-1}$

$$\begin{bmatrix} C\theta_{23} & -S\theta_{23} & 0 & l_2C\theta_2 + l_3C\theta_{23} \\ S\theta_{23} & C\theta_{23} & 0 & l_2S\theta_2 + l_3S\theta_{23} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} =$$

$$\begin{bmatrix} r_{11}C\theta_1 + r_{21}S\theta_1 & r_{12}C\theta_1 + r_{22}S\theta_1 & r_{13}C\theta_1 + r_{23}S\theta_1 & p_xC\theta_1 + p_yS\theta_1 - l_1 \\ -r_{31} & -r_{32} & -r_{33} & -p_z \\ -r_{11}S\theta_1 + r_{21}C\theta_1 & -r_{12}S\theta_1 + r_{22}C\theta_1 & -r_{13}S\theta_1 + r_{23}C\theta_1 & -p_xS\theta_1 + p_yC\theta_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Comparing both sides and solving the equations, the angles are given by:

$$\theta_1 = \tan^{-1}\frac{p_y}{p_x} \qquad (7)$$

$$\theta_2 = \sin^{-1}\frac{l_3 r_{31} - p_z}{l_2} \qquad (8)$$

$$\theta_3 = \tan^{-1}\frac{r_{31}}{r_{32}} - \theta_2 \qquad (9)$$

**Velocity and acceleration analysis of thumb**

The joint trajectories have already been defined as:

$$\theta_1 = 540t^2 - 360t^3$$
$$\theta_2 = 72t^2 - 48t^3$$
$$\theta_3 = 72t^2 - 48t^3$$

Therefore, the joint velocities are:

$$\dot{\theta}_1 = \frac{d\theta_1}{dt}, \dot{\theta}_2 = \frac{d\theta_2}{dt}, \dot{\theta}_3 = \frac{d\theta_3}{dt} \qquad (10)$$

The joint accelerations are:

$$\ddot{\theta}_1 = \frac{d\dot{\theta}_1}{dt}, \ddot{\theta}_2 = \frac{d\dot{\theta}_2}{dt}, \ddot{\theta}_3 = \frac{d\dot{\theta}_3}{dt} \qquad (11)$$

From the forward kinematics, the position of the end effector as:

$$X = l_1 C\theta_1 + l_2 C\theta_1 C\theta_2 + l_3 C\theta_1 C\theta_2 C\theta_3 - l_3 C\theta_1 S\theta_2 S\theta_3 + 60$$
$$Y = l_2 S\theta_2 + l_3 S\theta_{23}$$
$$Z = l_1 S\theta_1 + l_2 S\theta_1 C\theta_2 + l_3 S\theta_1 C\theta_2 C\theta_3 - l_3 S\theta_1 S\theta_2 S\theta_3 + 25$$

The velocity of the end effector is given by:

$$\dot{X} = \frac{dX}{dt}, \dot{Y} = \frac{dY}{dt}, \dot{Z} = \frac{dZ}{dt} \qquad (12)$$

The acceleration of the end effector is given by:

$$\ddot{X} = \frac{d\dot{X}}{dt}, \ddot{Y} = \frac{d\dot{Y}}{dt}, \ddot{Z} = \frac{d\dot{Z}}{dt} \qquad (13)$$

**B. Kinematics of rest fingers**

Rest of the fingers are identical with link lengths being the only variant. So, their analysis remains same, parametrically. The DH parameter representation of the fingers is shown below (just for reference the numerical values of the index fingers are shown):

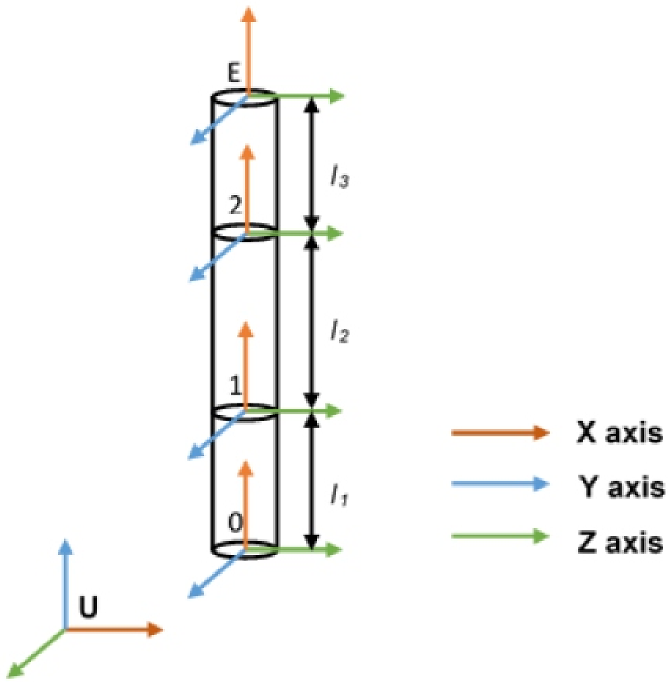


Fig 6: Denavit- Hartenberg parameter model of Index finger

**Table 3: Denavit- Hartenbag parameter of index finger**

| Frame | $\theta_{i(degree)}$ | $d_{i(mm)}$ | $\alpha_{i(degree)}$ | $a_{i(mm)}$ |
|---|---|---|---|---|
| 0-1 | $\theta_1$ | 0 | 0 | $l_1$= 31 |
| 1-2 | $\theta_2$ | 0 | 0 | $l_2$= 27 |
| 2-E | $\theta_3$ | 0 | 0 | $l_3$= 29 |

**Forward Kinematics of rest finger**

Once again, cubic trajectory has been assigned to each joint: $\theta_i = a_0 + a_1 t + a_2 t^2 + a_3 t^3$ .The range of motions of each joint has been presented below in Table 4:

**Table 4: Range of motion of each joint of index finger**

| $\theta_i$ | $\theta_i$ (deg) | $\theta_f$ (deg) | $\dot{\theta}_i$ (deg/s) | $\dot{\theta}_f$ (deg/s) | $t_i$ (s) | $t_f$ (s) |
|---|---|---|---|---|---|---|
| $\theta_1 = 135t^2 - 90t^3$ | 0 | 180 | 0 | 0 | 0 | 1 |
| $\theta_2 = 120t^2 - 80t^3$ | 0 | 24 | 0 | 0 | 0 | 1 |
| $\theta_3 = 120t^2 - 80t^3$ | 0 | 24 | 0 | 0 | 0 | 1 |

The position and orientation of a frame with respect to its previous frame is given by the following homogeneous transformation matrix:

$$ {}^{i-1}_{i}T = \begin{bmatrix} C\theta_i & -S\theta_2 C\alpha_i & S\theta_i S\alpha_i & a_i C\theta_i \\ S\theta_i & C\theta_i C\alpha_i & -C\theta_i S\alpha_i & a_i S\theta_i \\ 0 & S\alpha_i & C\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

Where, $C\theta_i = \cos\theta_i$ , $S\theta_i = \sin\theta_i$ ,

$C\alpha_i = \cos\alpha_i \;\; S\alpha_i = \sin\alpha_i$

$$ {}^{0}_{E}T = {}^{0}_{1}T \times {}^{1}_{2}T \times {}^{2}_{E}T $$

Similar from Equation (1) represents the homogenous transformation matrix of end effector frame with respect to the base coordinate frame.

$$ {}^{0}_{E}T = \begin{bmatrix} C\theta_{123} & -S\theta_{123} & 0 & L_1 C\theta_1 + L_2 C\theta_{12} + L_3 C\theta_{123} \\ S\theta_{123} & -C\theta_{123} & 0 & L_1 S\theta_1 + L_2 S\theta_{12} + L_3 S\theta_{123} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

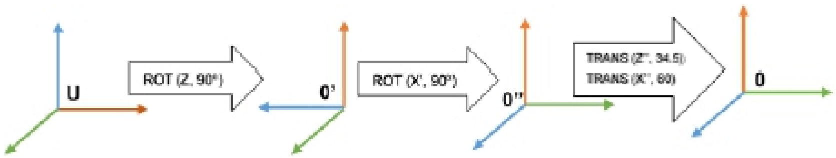


**Fig 7: Position mapping model of thumb**

The mapping is given by: $H = Rot(Z, 90^0) \times Rot(X', 90^0) \times Trans(Z'', 34.5) \times Trans(X'', 60)$ (14)

$$ H = \begin{bmatrix} C90^0 & -S90^0 & 0 & 0 \\ S90^0 & C90^0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & C90^0 & -S90^0 & 0 \\ 0 & S90^0 & C90^0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ \times \begin{bmatrix} 1 & 0 & 0 & 60 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 34.5 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$H = \begin{bmatrix} 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 60 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 34.5 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$H = \begin{bmatrix} 0 & 0 & 1 & 34.5 \\ 1 & 0 & 0 & 60 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The final position and orientation matrix with respect to the universal frame is given by similar equation (3):

$${}^{U}_{E}T = H \times {}^{0}_{E}T$$

$${}^{U}_{E}T = \begin{bmatrix} 0 & 0 & 1 & 34.5 \\ C\theta_{123} & -S\theta_{123} & 0 & l_1 C\theta_1 + l_2 C\theta_{12} + l_3 C\theta_{123} + 60 \\ S\theta_{123} & C\theta_{123} & 0 & l_1 S\theta_1 + l_2 S\theta_{12} + l_3 S\theta_{123} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

So, the position of the end effector is given as:

$$X = 34.5 \quad (15)$$

$$Y = l_1 C\theta_1 + l_2 C\theta_{12} + l_3 C\theta_{123} + 60 \quad (16)$$

$$Z = l_1 S\theta_1 + l_2 S\theta_{12} + l_3 S\theta_{123} \quad (17)$$

**Inverse Kinematics of rest finger**

It turns out that the inverse kinematic solutions of the other three fingers is same as that of a standard 3 link planar arm. Therefore, the solutions are

$$\theta_2 = \cos^{-1} \frac{w_x^{\,2} + w_y^{\,2} - l_1^{\,2} - l_2^{\,2}}{2 l_1 l_2} \quad (18)$$

$$\theta_1 = \sin^{-1} \frac{(l_1 + l_2 \cos\theta_2) w_y - l_2 \sin\theta_2 w_x}{\Delta} \quad (19)$$

$$\theta_3 = \cos^{-1} \frac{X - l_1 \cos\theta_1 - l_2 \cos(\theta_1 + \theta_2)}{l_3} - \theta_1 - \theta_2 \quad (20)$$

Where

$w_x = X$ coordinate of $2^{nd}$ joint

$w_y = Y$ coordinate of $2^{nd}$ joint

$$\Delta = l_1^2 + l_2^2 + 2l_1l_2\cos\theta_2 = w_x^2 + w_y^2$$

**Velocity and acceleration analysis of rest finger**

The velocity and acceleration analysis is similar to that of the thumb.

## IV. DYNAMIC ANALYSIS OF THE HAND

Dynamic analysis is one of the major parts of robotic manipulation and development of control algorithm. Dynamic analysis basically deals with the calculation of joint forces or torques, when a body is in a state of motion or rest. Force calculation for body in rest is called static force analysis and when it is applied on a moving body is called kinetics. However, the sense of practicality lies on the combination of both the cases. The Lagrange- Euler formulation has been used for calculation of joint torques.

This method utilizes the kinetic energy and potential energy of the hand manipulator. The deformability of the body was completely ignored here. In this section, the dynamic analysis of the hand manipulator has been carried out in three different ways A) motion dynamics without static force B) static force analysis and C) motion dynamics with static force. All the analyses have been done for thumb and index finger. The analyses of the other three fingers are similar to that of the index fingers. The detailed methodology of the dynamic analyses is as follows.

### A. Motion dynamics without static force

The basic idea behind this is to find out the joint torques when a serial manipulator is moving from one place to another one without considering the end effector force. The equation of the joint torque is

$$\tau_i = \frac{d}{dt}\left(\frac{\delta L}{\delta \dot{\theta}_i}\right) - \frac{\delta L}{\delta \theta_i} \qquad (21)$$

Where, $\tau_i$ = torque on $i^{th}$ joint

L= Lagrangian

L can be defined as given below

L= K-P

K = kinetic energy

P= potential energy

$\theta_i$ = angular displacement of $i^{th}$ rotational joint

$\dot{\theta}_i$ = angular velocity of $i^{th}$ rotational joint

**Torque calculation for thumb**

In this design, the thumb has three degrees of freedom. The second and the third joint moves in a plane perpendicular to the plane of motion of the first joint. Clearly, there are three joint torques. The full analyses are given below:

**Development of Joint torque equation for thumb**

Before finding out the equations of the joint torques, it is necessary to compute kinetic and potential energy of every link.

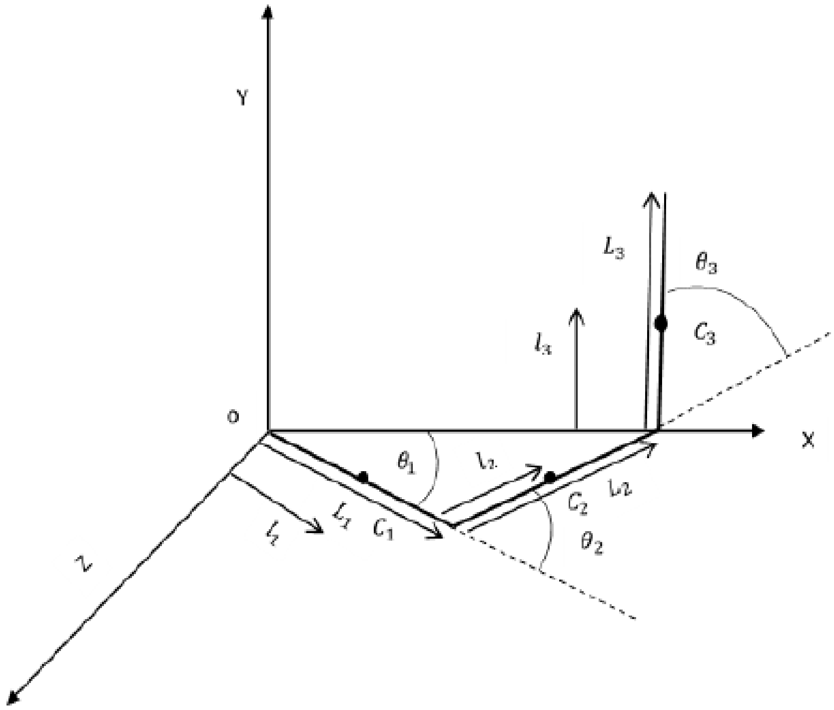


**Fig 8: Thumb geometry**

**Link-1**

Position of center of mass of first link:

$$x_1 = l_1 \cos\theta_1 \,,\, y_1 = 0 \,,\, z_1 = l_1 \sin\theta_1$$

$$\text{linear velocity, } v_1^2 = \dot{x}_1^2 + \dot{y}_1^2 + \dot{z}_1^2$$

$$\text{kinetic energy, } KE_1 = \frac{1}{2} I_1 \omega_1^2 + \frac{1}{2} m_1 v_1^2$$

$$\text{Where, } I_1 = I \text{ about } C_1$$

$$\text{Angular velocity, } \omega_1^2 = \dot{\theta}_1^2$$

$$\text{Potential energy, } PE_1 = 0$$

**Link-2**

Position of center of mass of second link:

$$x_2 = L_1 \cos\theta_1 + l_2 \cos\theta_2 \cos\theta_1$$

$$y_2 = L_2 \sin\theta_2$$

$$z_2 = L_1 \sin\theta_1 + l_2 \cos\theta_2 \sin\theta_1$$

$$\text{linear velocity, } v_2^2 = \dot{x}_2^2 + \dot{y}_2^2 + \dot{z}_2^2$$

$$\text{kinetic energy, } KE_2 = \frac{1}{2} I_2 \omega_2^2 + \frac{1}{2} m_2 v_2^2$$

Where, $I_2 = I$ about $C_2$

Angular velocity, $\omega_2^2 = \dot{\theta}_1^2 + \dot{\theta}_2^2$

Potential energy, $PE_2 = m_2 g(l_2 \sin\theta_2)$

**Link -3**

Position of center of mass of third link:

$$x_3 = [L_1 + l_2\cos\theta_2 + l_3\cos\theta_1\cos(\theta_2+\theta_3)]\cos\theta_1$$

$$y_3 = L_2\sin\theta_2 + l_3\sin(\theta_2+\theta_3)$$

$$z_3 = [L_1 + l_2\cos\theta_2 + l_3\cos(\theta_2+\theta_3)]\sin\theta_1$$

linear velocity, $v_3^2 = \dot{x}_3^2 + \dot{y}_3^2 + \dot{z}_3^2$

kinetic energy, $KE_3 = \frac{1}{2}I_3\omega_3^2 + \frac{1}{2}m_3 v_3^2$

Where, $I_3 = I$ about $C_3$

Angular velocity, $\omega_3^2 = \dot{\theta}_1^2 + \left(\dot{\theta}_2 + \dot{\theta}_3\right)^2$

Potential energy, $PE_3 = m_3 g(L_2\sin\theta_2 + l_3\sin(\theta_2+\theta_3))$

**Lagrange-Euler equation of motion for thumb**

$$\tau_1 = \frac{d}{dt}\left(\frac{\delta L}{\delta\dot{\theta}_1}\right) - \frac{\delta L}{\delta\theta_1}$$
$$= (I_1+I_2+I_3)\ddot{\theta}_1 + m_1 l_1^2\ddot{\theta}_1 + m_2(L_1+l_2C_2)^2\ddot{\theta}_1$$
$$-2m_2(L_1+l_2C_2)S_2\dot{\theta}_2\dot{\theta}_1 + m_3\ddot{\theta}_1(L_1+L_2C_2+l_3C_{23})^2$$
$$-2m_3(L_1+L_2C_2+l_3C_{23})(L_2S_2\dot{\theta}_2 + l_3S_{23}\dot{\theta}_{23})\dot{\theta}_1 \quad (22)$$

$$\tau_2 = \frac{d}{dt}\left(\frac{\delta L}{\delta\dot{\theta}_2}\right) - \frac{\delta L}{\delta\theta_2}$$
$$= [I_2\ddot{\theta}_2 + m_2 l_2^2\ddot{\theta}_2] + [I_3\ddot{\theta}_{23} + m_3\{L_2^2\ddot{\theta}_2 + l_3^2\ddot{\theta}_{23} +$$
$$L_2l_3C_3(2\ddot{\theta}_2 + \ddot{\theta}_3) - L_2l_3S_3\dot{\theta}_3(2\dot{\theta}_2 + \dot{\theta}_3) +$$
$$m_2[\dot{\theta}_1^2(L_1+l_2C_2)(l_2S_2)]$$
$$+m_3[\dot{\theta}_1^2(L_1+L_2C_2+l_3C_{23})(L_2S_2+l_3S_{23})]$$
$$+m_2gl_2C_2 + m_3g(L_2C_2+l_3C_{23}) \quad (23)$$

$$\tau_3 = \frac{d}{dt}\left(\frac{\delta L}{\delta\dot{\theta}_3}\right) - \frac{\delta L}{\delta\theta_3}$$
$$= [I_3\ddot{\theta}_{23} + m_3(l_3^2\ddot{\theta}_{23} + L_2l_3C_3\ddot{\theta}_2 - L_2l_3S_3\dot{\theta}_3\dot{\theta}_2)]$$
$$+m_3[\dot{\theta}_1^2(L_1+L_2C_2+l_3C_{23})(l_3S_{23}) + L_2l_3S_3\dot{\theta}_2\dot{\theta}_{23}]$$
$$+m_3gl_3C_{23} \quad (24)$$

**Development of Joint torque equation for index finger**

This finger also has 3 degrees of freedom but all the joints move in the same plane and that's why its torque equations are little bit different from the thumb. The torque equation of index finger is given below:

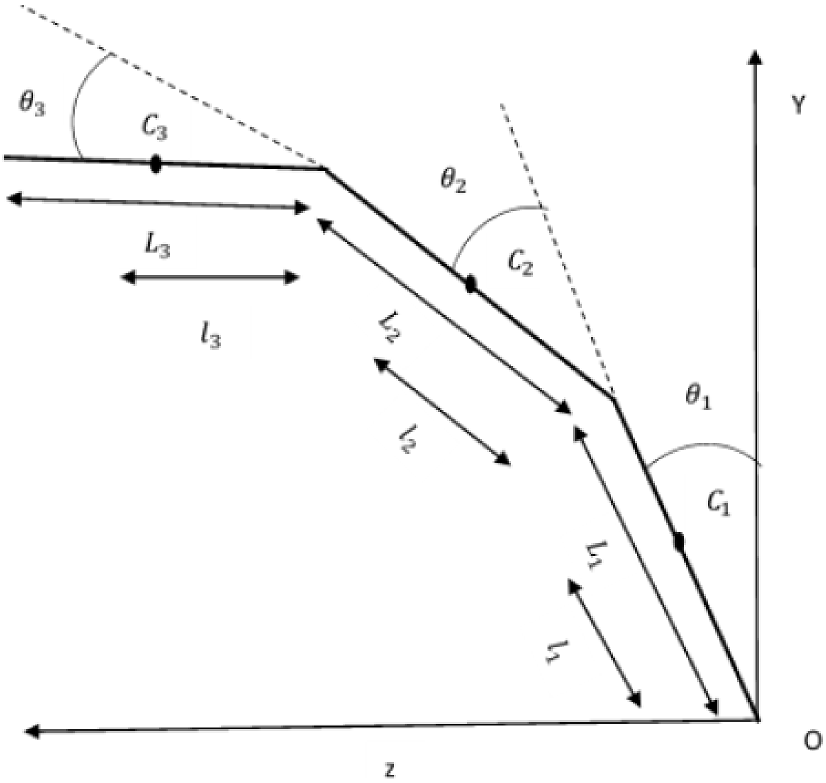


**Fig 9: Index finger geometry**

**Link-1**

Position of center of mass of first link:

$$x_1 = 0$$

$$y_1 = l_1 \cos\theta_1$$

$$z_1 = l_1 \sin\theta_1$$

linear velocity, $v_1^2 = \dot{x}_1^2 + \dot{y}_1^2 + \dot{z}_1^2$

kinetic energy, $KE_1 = \frac{1}{2} I_1 \omega_1^2 + \frac{1}{2} m_1 v_1^2$

Where, $I_1 = I$ about $C_1$

Angular velocity, $\omega_1^2 = \dot{\theta}_1^2$

Potential energy, $PE_1 = m_1 g (l_1 \cos\theta_1)$

**Link-2**

Position of center of mass of second link:

$$x_2 = 0$$

$$y_2 = L_1 \cos\theta_1 + l_2 \cos(\theta_1 + \theta_2)$$

$$z_2 = L_1 \sin\theta_1 + l_2 \sin(\theta_1 + \theta_2)$$

linear velocity, $v_2^2 = \dot{x}_2^2 + \dot{y}_2^2 + \dot{z}_2^2$

kinetic energy, $KE_2 = \frac{1}{2} I_2 \omega_2^2 + \frac{1}{2} m_2 v_2^2$

Where, $I_2 = I$ about $C_2$

Angular velocity, $\omega_2^2 = \left(\dot{\theta}_1 + \dot{\theta}_2\right)^2$

Potential energy, $PE_2 = m_2 g[L_1 \cos\theta_1 + l_2 \cos(\theta_1 + \theta_2)]$

**Link -3**

Position of center of mass of third link:

$x_3 = 0$

$y_3 = L_1 \cos\theta_1 + L_2 \cos(\theta_1 + \theta_2) + l_3 \cos(\theta_1 + \theta_2 + \theta_3)$

$z_3 = L_1 \sin\theta_1 + L_2 \sin(\theta_1 + \theta_2) + l_3 \sin(\theta_1 + \theta_2 + \theta_3)$

linear velocity, $v_3^2 = \dot{x}_3^2 + \dot{y}_3^2 + \dot{z}_3^2$

kinetic energy, $KE_3 = \frac{1}{2} I_3 \omega_3^2 + \frac{1}{2} m_3 v_3^2$

Where, $I_3 = I$ about $C_3$

Angular velocity, $\omega_3^2 = \left(\dot{\theta}_1 + \dot{\theta}_2 + \dot{\theta}_3\right)^2$

Potential energy,

$PE_3 = m_3 g[L_1 \cos\theta_1 + L_2 \cos(\theta_1 + \theta_2) + l_3 \cos(\theta_1 + \theta_2 + \theta_3)]$

**Lagrange-Euler equation**

$$
\begin{aligned}
\tau_1 &= \frac{d}{dt}\left(\frac{\delta L}{\delta \dot{\theta}_1}\right) - \frac{\delta L}{\delta \theta_1} \\
&= [I_1 \ddot{\theta}_1 + m_1 l_1^2 \ddot{\theta}_1] \\
&+ [I_2 \ddot{\theta}_{12} + m_2 \{L_1^2 \ddot{\theta}_1 + l_2^2 \ddot{\theta}_{12} + L_1 l_2 C_2 (2\ddot{\theta}_1 + \ddot{\theta}_2) \\
&- L_1 l_2 S_2 \dot{\theta}_2 (2\dot{\theta}_1 + \dot{\theta}_2)\}] \\
&+ [I_3 \ddot{\theta}_{123} + m_3 \{L_1^2 \ddot{\theta}_1 + L_2^2 \ddot{\theta}_{12} + l_3^2 \ddot{\theta}_{123} + \\
& L_1 L_2 C_2 (2\ddot{\theta}_1 + \ddot{\theta}_2) - L_1 L_2 S_2 \dot{\theta}_2 (2\dot{\theta}_1 + \dot{\theta}_2) \\
&+ L_2 l_3 C_3 (2\ddot{\theta}_1 + 2\ddot{\theta}_2 + \ddot{\theta}_3) - \\
& L_2 l_3 S_3 \dot{\theta}_3 (2\dot{\theta}_1 + 2\dot{\theta}_2 + \dot{\theta}_3) + L_2 l_3 C_{23} (2\ddot{\theta}_1 + \ddot{\theta}_2 + \ddot{\theta}_3) \\
&- L_2 l_3 S_{23} \dot{\theta}_{23} (2\dot{\theta}_1 + \dot{\theta}_2 + \dot{\theta}_3)\}] \\
&- g[m_1 l_1 S_1 + m_2 L_1 S_1 + m_2 l_2 S_{12} + m_3 L_1 S_1 \\
&+ m_3 L_2 S_{12} + m_3 l_3 S_{123}]
\end{aligned} \quad (25)
$$

$$\tau_2 = \frac{d}{dt}\left(\frac{\delta L}{\delta \dot{\theta}_2}\right) - \frac{\delta L}{\delta \theta_2}$$

$$= [I_2\ddot{\theta}_{12} + m_2\{l_2^2\ddot{\theta}_{12} + L_1 l_2 \ddot{\theta}_1 C_2 - L_1 l_2 \dot{\theta}_1 \dot{\theta}_2 S_2]$$

$$+[I_3\ddot{\theta}_{123} + m_3\{L_2^2\ddot{\theta}_{12} + l_3^2\ddot{\theta}_{123} + L_1 L_2 C_2 \ddot{\theta}_1 - L_1 L_2 S_2 \dot{\theta}_2 \dot{\theta}_1$$

$$+L_2 l_3 C_3(2\ddot{\theta}_2 + 2\ddot{\theta}_2 + \ddot{\theta}_3) - L_2 l_3 S_3 \dot{\theta}_3(2\dot{\theta}_2 + 2\dot{\theta}_2 + \dot{\theta}_3)$$

$$+L_1 l_3 C_{23}\ddot{\theta}_1 - L_1 l_3 S_{23}\dot{\theta}_{23}\dot{\theta}_1\}]$$

$$+[m_2 L_1 l_2 \dot{\theta}_1 \dot{\theta}_{12} S_2 + m_3 L_1 L_2 S_2 \dot{\theta}_1 \dot{\theta}_{12} + m_3 L_1 l_3 S_{23} \dot{\theta}_1 \dot{\theta}_{123}]$$

$$-g[m_2 l_2 S_{12} + m_3 L_2 S_{12} + m_3 l_3 S_{123}] \quad (26)$$

$$\tau_3 = \frac{d}{dt}\left(\frac{\delta L}{\delta \dot{\theta}_3}\right) - \frac{\delta L}{\delta \theta_3}$$

$$= [I_3\ddot{\theta}_{123} + m_3(l_3^2\ddot{\theta}_{123} + L_2 l_3 C_3 \ddot{\theta}_{12}$$

$$-L_2 l_3 S_3 \dot{\theta}_3 \dot{\theta}_{12} + L_1 l_3 C_{23}\ddot{\theta}_1$$

$$-L_1 l_3 S_{23}\dot{\theta}_{23}\dot{\theta}_1)] + m_3[L_2 l_3 S_3 \dot{\theta}_{12}\dot{\theta}_{123} + L_1 l_3 S_{23}\dot{\theta}_1\dot{\theta}_{123}]$$

$$+m_3 g l_3 S_{123} \quad (27)$$

**B. Static force**

It is basically the torque required by a joint under static condition. A static force is applied at the end effector whose orientation is specified in accordance with the end effector frame. Due to this force the joint generates a sustainable torque which has to be solved in this section. Gravity term was completely neglected in this particular analysis. The joint has to be considered as a fixed joint in order to carry out the analysis. The joint torque is given by

$$\tau = J^T F \quad (28)$$

The above equation basically represents the relationship between joint torque vector (τ) and end effector load (F) vector [11].

Where,

$J^T$ = transpose of Jacobin matrix of the end effector position

F= force vector

**Static force analysis for thumb**

Where, Jacobian matrix

$$J = \begin{bmatrix} \frac{\delta p_x}{\delta \theta_1} & \frac{\delta p_x}{\delta \theta_2} & \frac{\delta p_x}{\delta \theta_3} \\ \frac{\delta p_y}{\delta \theta_1} & \frac{\delta p_y}{\delta \theta_2} & \frac{\delta p_y}{\delta \theta_3} \\ \frac{\delta p_z}{\delta \theta_1} & \frac{\delta p_z}{\delta \theta_2} & \frac{\delta p_z}{\delta \theta_3} \end{bmatrix}$$

And force-moment matrix

$$F = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

$$\text{Hence, } \tau = \begin{bmatrix} 0 \\ -\{L_3 \cos(\theta_2 + \theta_3) + L_2 \cos\theta_2\} \\ -\{L_3 \cos(\theta_2 + \theta_3)\} \end{bmatrix}$$

$$\tau_{s1} = 0 \quad (29)$$

$$\tau_{s2} = -\{L_3 \cos(\theta_2 + \theta_3) + L_2 \cos\theta_2\} \quad (30)$$

$$\tau_{s3} = -\{L_3 \cos(\theta_2 + \theta_3)\} \quad (31)$$

**Static force analysis for index finger:**

Where, Jacobian matrix

$$J = \begin{bmatrix} \frac{\delta p_x}{\delta\theta_1} & \frac{\delta p_x}{\delta\theta_2} & \frac{\delta p_x}{\delta\theta_3} \\ \frac{\delta p_y}{\delta\theta_1} & \frac{\delta p_y}{\delta\theta_2} & \frac{\delta p_y}{\delta\theta_3} \\ \frac{\delta p_z}{\delta\theta_1} & \frac{\delta p_z}{\delta\theta_2} & \frac{\delta p_z}{\delta\theta_3} \end{bmatrix}$$

And force-moment matrix

$$F = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$$

Hence,

$$\tau = \begin{bmatrix} L_2 \cos(\theta_1 + \theta_2) + L_1 \cos\theta_1 + L_3 \cos(\theta_1 + \theta_2 + \theta_3) \\ L_2 \cos(\theta_1 + \theta_2) + L_3 \cos(\theta_1 + \theta_2 + \theta_3) \\ L_3 \cos(\theta_1 + \theta_2 + \theta_3) \end{bmatrix}$$

$$\tau_{s1} = L_2 \cos(\theta_1 + \theta_2) + L_1 \cos\theta_1 + L_3 \cos(\theta_1 + \theta_2 + \theta_3) \quad (32)$$

$$\tau_{s2} = L_2 \cos(\theta_1 + \theta_2) + L_3 \cos(\theta_1 + \theta_2 + \theta_3) \quad (33)$$

$$\tau_{s3} = L_3 \cos(\theta_1 + \theta_2 + \theta_3) \quad (34)$$

**C. Motion dynamics with static force**

It is the combination of motion dynamics with no load condition and static force analysis. It involves finding out the torque when the body carries a load as well as generate the desired motion (similar to pick and place operation). The equation of joint torque is therefore

$$\tau_{fi} = \tau_i + \tau_{si} \quad (35)$$

## V. CONTROL

Control of the manipulator is one of the important areas for precise design. It is used to regulate the movement of the manipulator minutely. To serve this purpose, this article implements a PID control technique. There are various techniques of PID control, but this paper follows the ADAMS-MATLAB COSIMULATION technique to serve this purpose. Here, the movement of the model, under the effect of the control system can be easily seen in the simulation.

To run this co-simulation, the basic block has been developed in Simulink and the control plant was imported from the ADAMS software. The imported plant is called ADAMS SUB-SYSTEM [15] which has been shown in Fig 10. ADAMS SUB-SYSTEM consist of the joint torques as input variables and angular displacements of the joints as output variables. The Simulink block diagram has been shown in Fig 11. where the PID control block was used to control the manipulator. Here, the control of the thumb has been shown. The control of rest of the fingers can be carried out along similar lines.

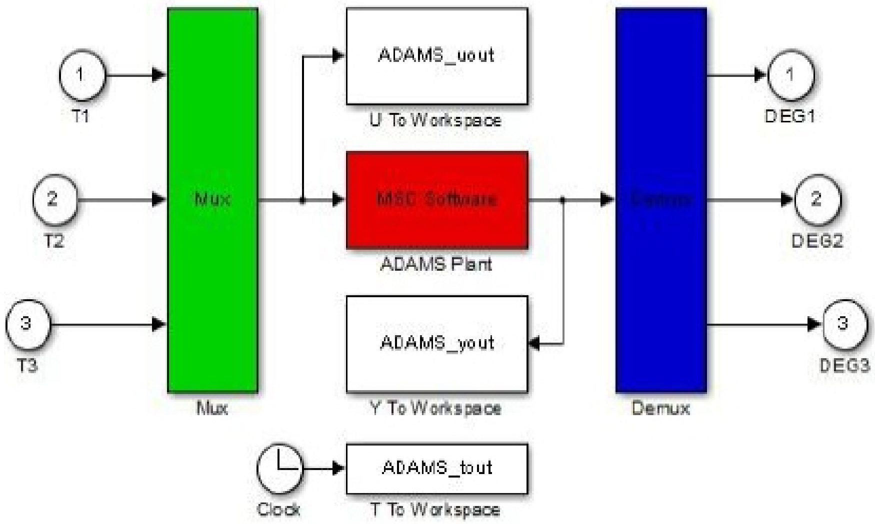


**Fig 10: ADAMS Subsystem**

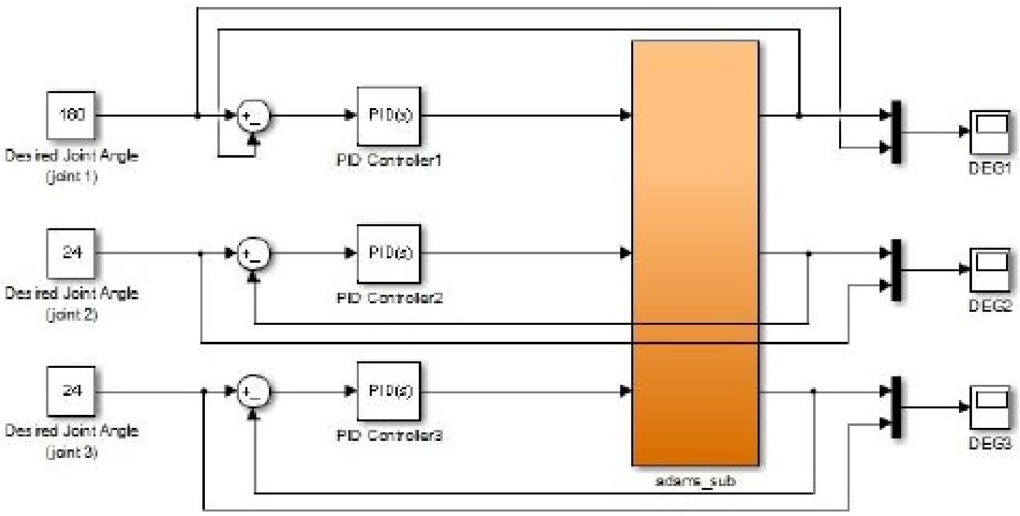


**Fig 11: Simulink Block Diagram for PID Control of the thumb**

## VI. RESULTS AND DISCUSSIONS

In this section, the results obtained from the theoretical calculations have been verified with the results of the simulation. The time history of the position, velocity, and acceleration of the end effectors of the fingers as well as the joint torques has been plotted in MATLAB and they were compared with the results obtained from ADAMS.

### A. Results from kinematic analysis

#### Results of the thumb

#### Forward kinematics of thumb

The comparison of the end effector's position, velocity and acceleration as well as the joint velocities and accelerations of the thumb are shown below:

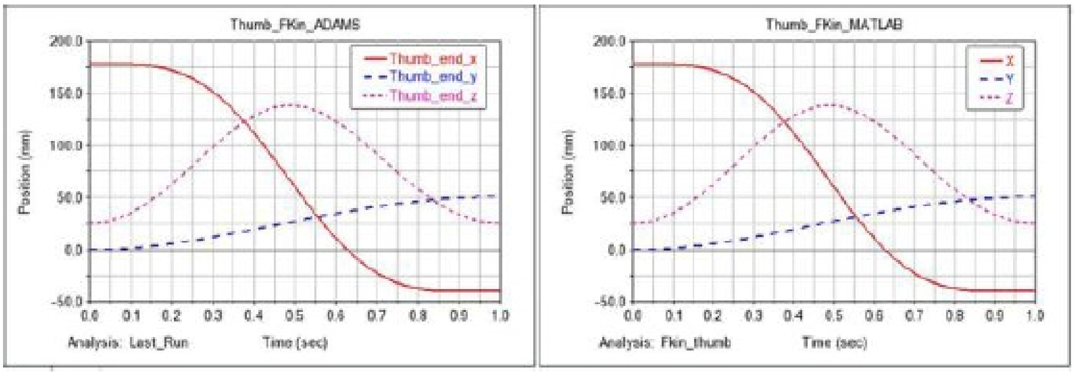


**Fig 12: Comparison of position plots of end effector from ADAMS and MATLAB**

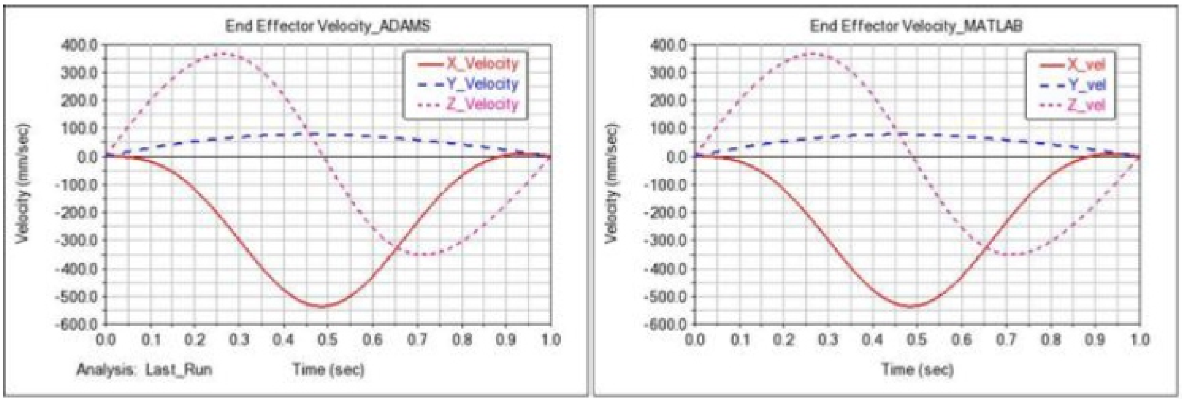


**Fig 13: Comparison of velocity plots of end effector from ADAMS and MATLAB**

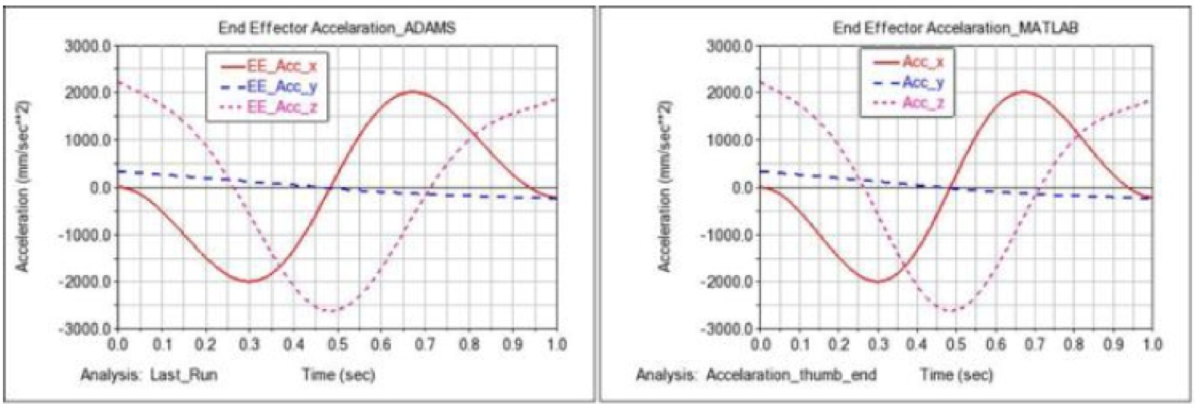


**Fig 14: Comparison of acceleration plots of end effector from ADAMS and MATLAB**

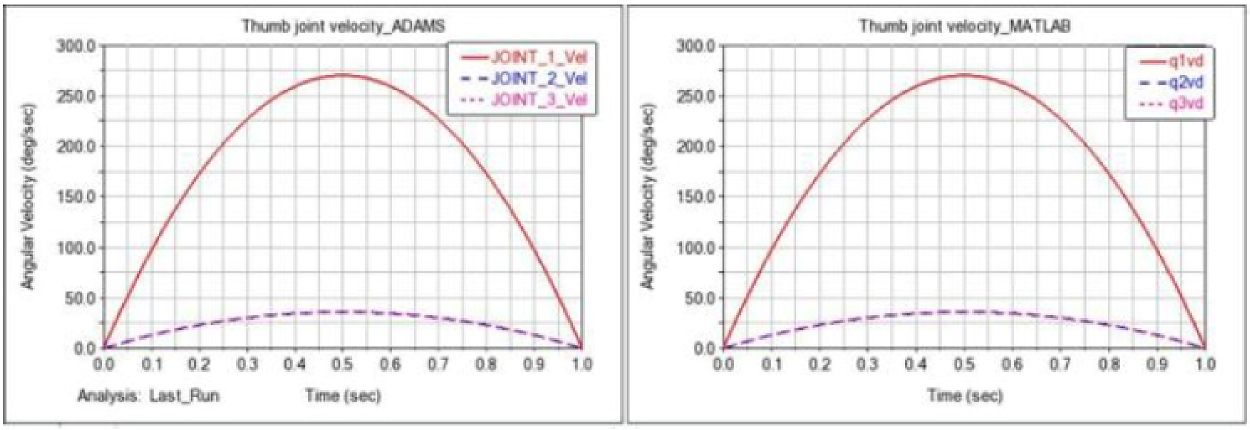


**Fig 15: Comparison of joint velocities of the thumb from ADAMS and MATLAB**

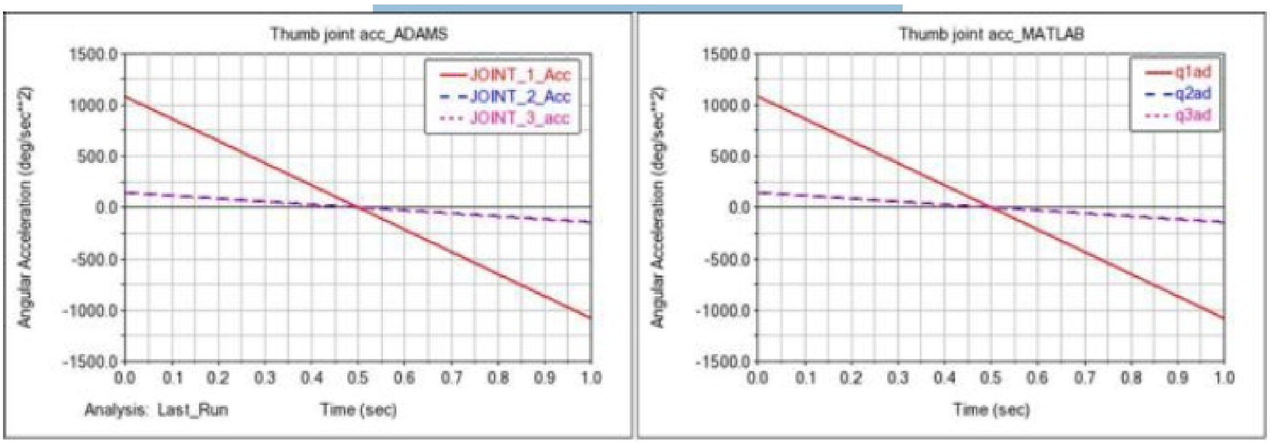


**Fig 16: Comparison of joint accelerations of the thumb from ADAMS and MATLAB**

### Inverse kinematics of thumb

In order to validate the inverse kinematic analysis, the transformation matrix (w.r.t. the first joint frame), that was obtained from the forward kinematics was used to figure out the angles and those were counter verified with the original joint trajectories. The comparison is shown below:

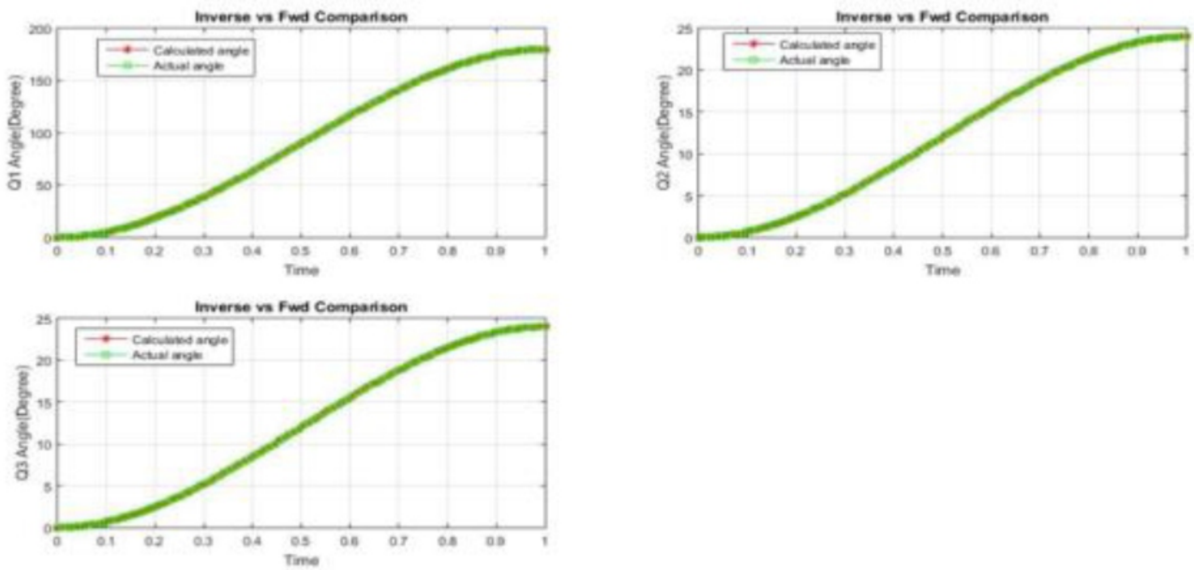


**Fig 17: Verification of inverse kinematic analysis in MATLAB**

**Results of the Index finger**

Operations similar to the thumb was carried out in this case also and the results are shown below:

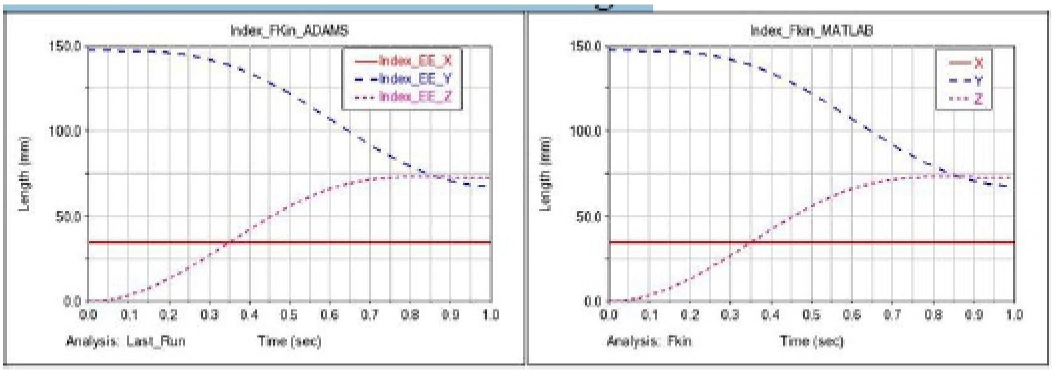


**Fig 18: Comparison of position plots of end effector from ADAMS and MATLAB**

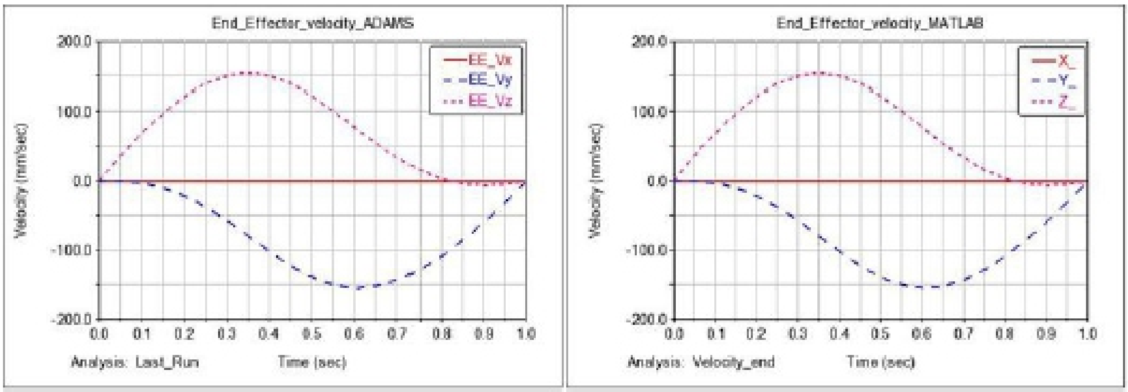


**Fig 19: Comparison of velocity plots of end effector from ADAMS and MATLAB**

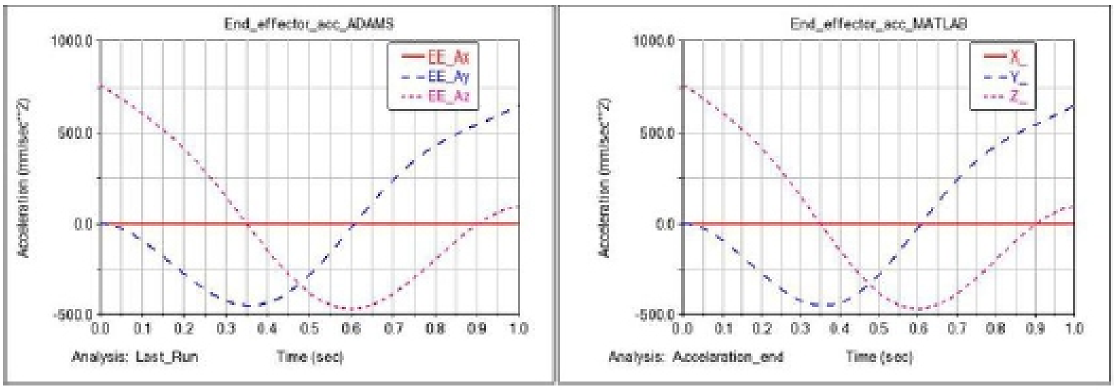


**Fig 20: Comparison of acceleration plots of end effector from ADAMS and MATLAB**

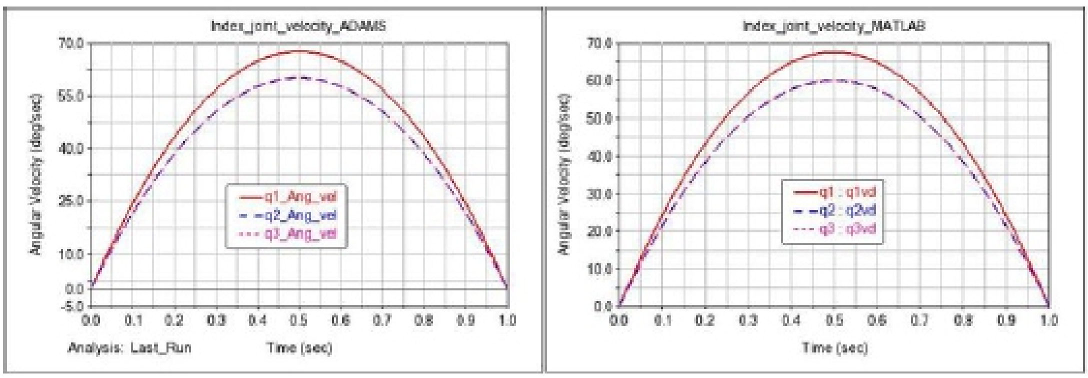


**Fig 21: Comparison of joint velocities of the thumb from ADAMS and MATLAB**

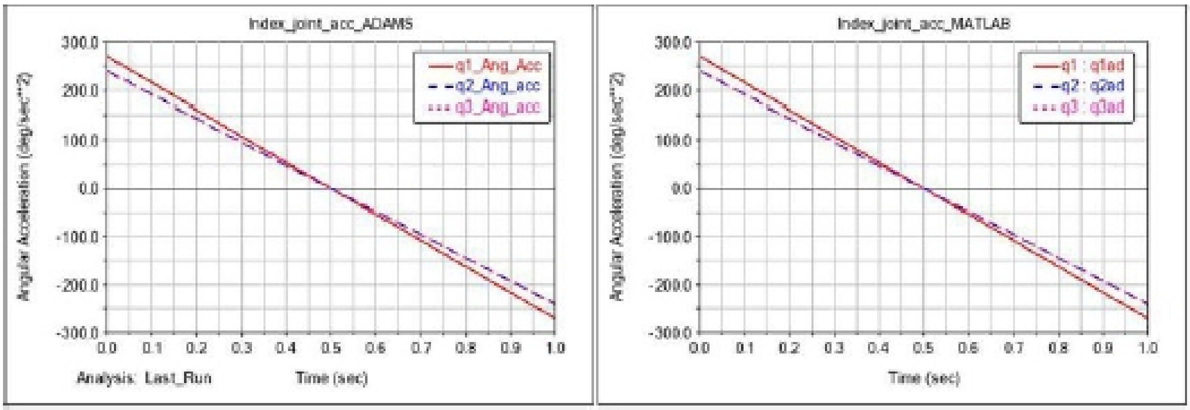


**Fig 22: Comparison of joint accelerations of the thumb from ADAMS and MATLAB**

**Inverse kinematics of index finger**

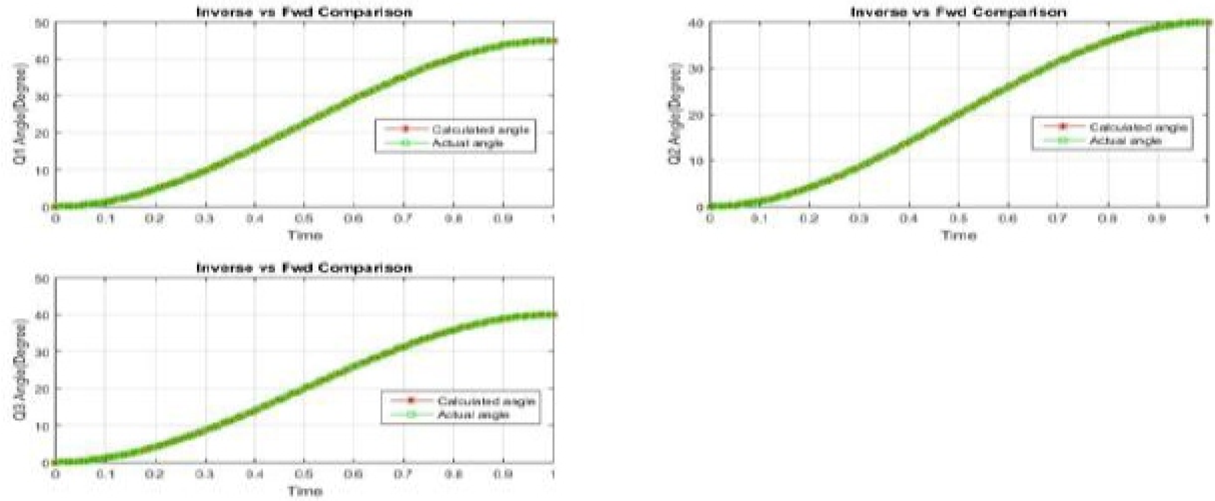


**Fig 23: Verification of inverse kinematic analysis in MATLAB**

The analyses of the rest of the three fingers are same as that of the index fingers with the link lengths being the only variants

**B. Results from dynamic analysis**

The results of the dynamic analyses have been divided into two parts viz. only due to a desired motion and secondly, considering a static force acting on the end effector along with the desired motion. It is to be noted that the latter is of greater practical importance as the static force symbolizes loads that would act on the fingers. Once again, the theoretical results have been verified with the simulation results. The results are shown below:

**Results of the Thumb**

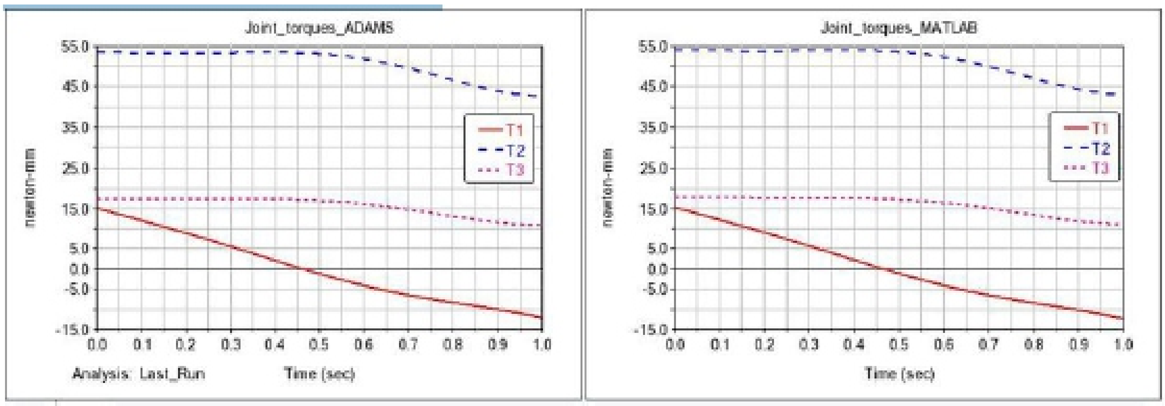


**Fig 24: Comparison of joint torques of the thumb (only due to motion) from ADAMS and MATLAB**

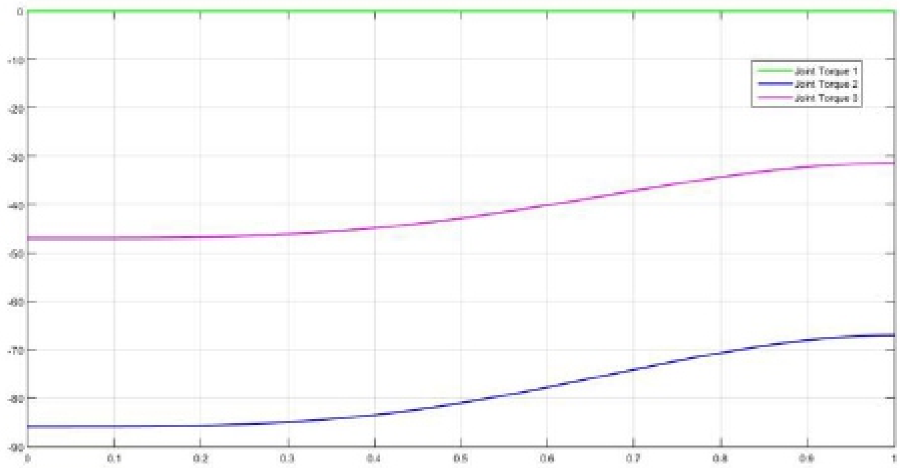

**Fig 25: Joint torques only due to static force**

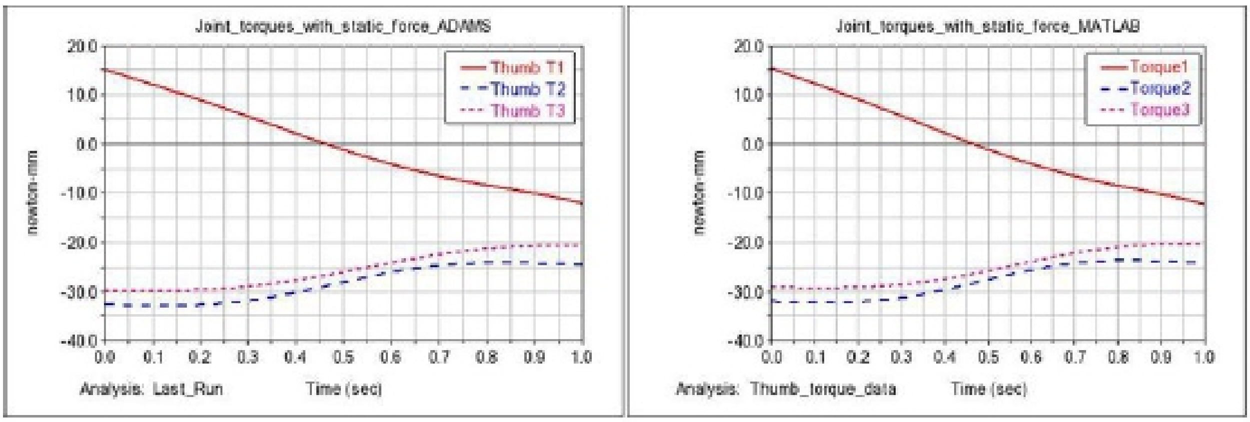


**Fig 26: Comparison of joint torques of the thumb (with added static force) from ADAMS and MATLAB**

**Results of the Index finger**

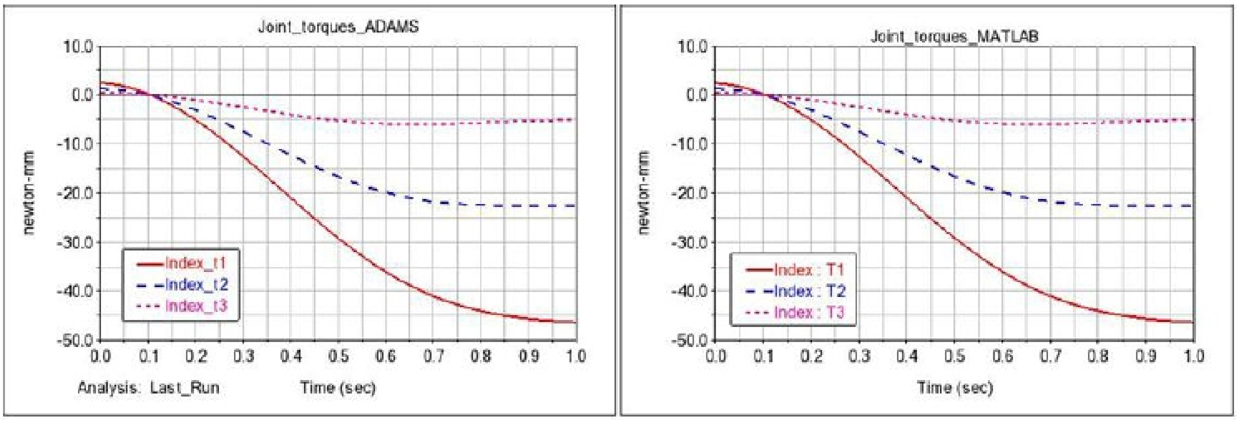


**Fig 27: Comparison of joint torques of the index finger (only due to motion) from ADAMS and MATLAB**

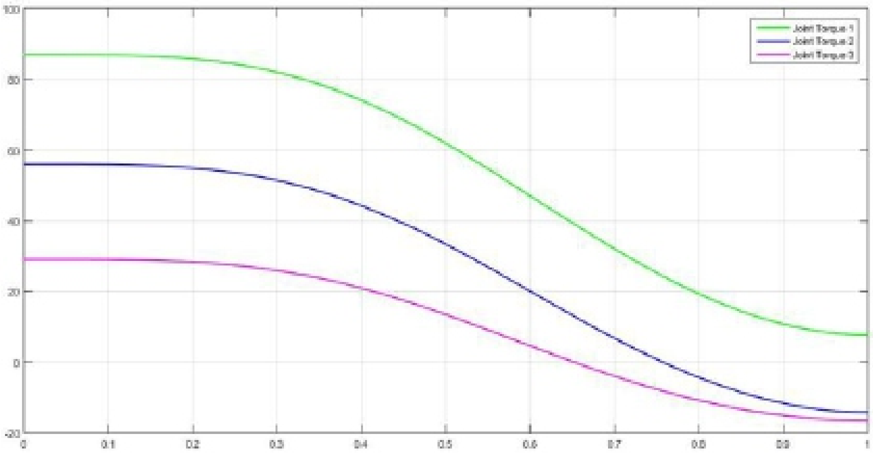

**Fig 28: Joint torques only due to static force**

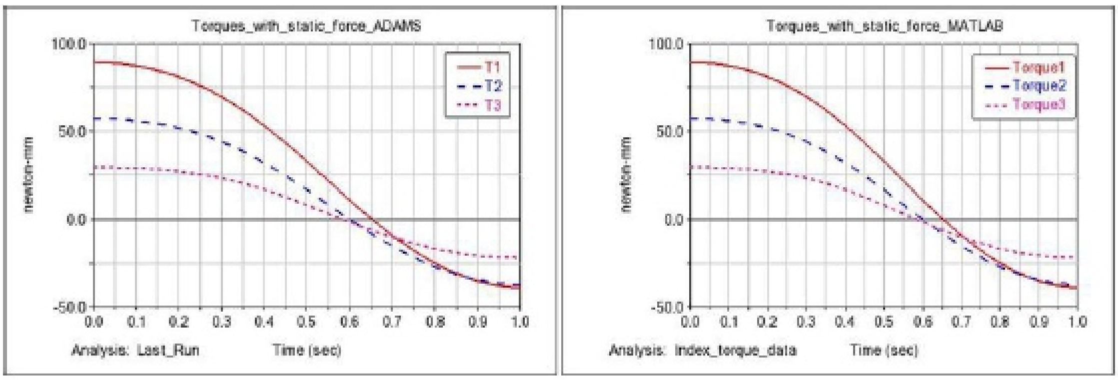


**Fig 29: Comparison of joint torques of the index finger (with added static force) from ADAMS and MATLAB**

## C. Results of control

The PID blocks were tuned so as to get the desired response. After going through an iterative process, the block parameters were found so as to get the desired response. The block parameters are:

**Table 7. Block parameters of the control system**

| Joint/ PID controller | P | I | D | N |
|---|---|---|---|---|
| 1 | -0.05 | -0.005 | 0.4 | 100 |
| 2 | 0.05 | -0.0588 | 0.0087 | 5 |
| 3 | 0.01 | -0.0128 | 0.007 | 4.5 |

**The responses (in this case, joint angles) for the 3 joints of the thumb are shown below:**

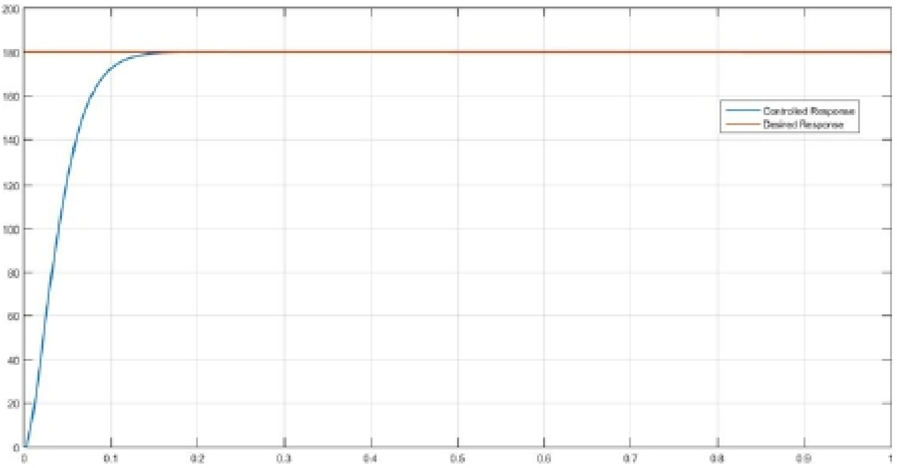


**Fig 30: Response of Joint 1**

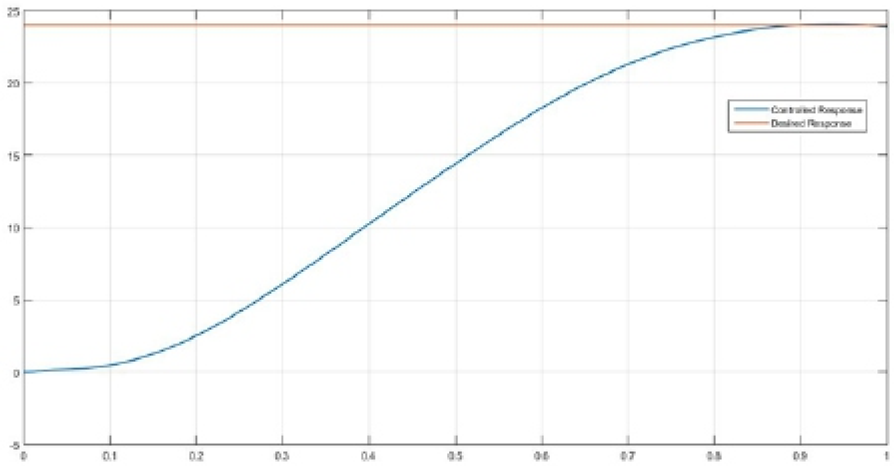


**Fig 31: Response of Joint 2**

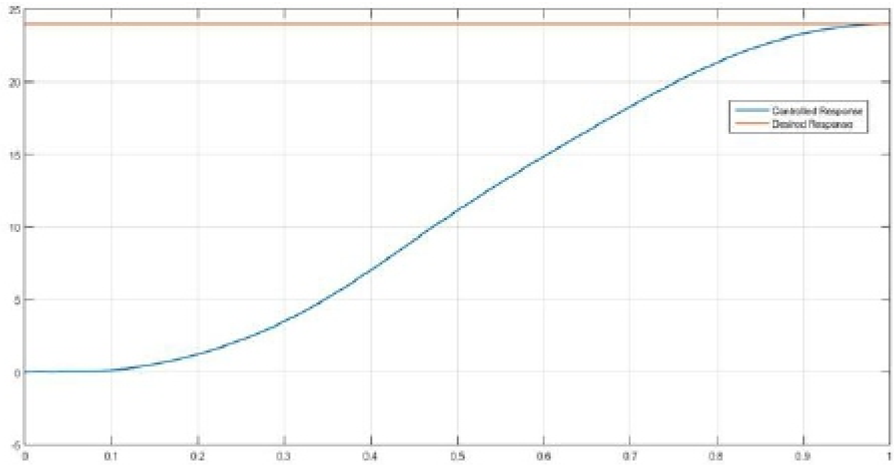


**Fig 32: Response of Joint 3**

The rise time or transient time for 2nd and 3rd joint is greater than that of the 1st joint.

## VII. CONCLUSIONS

In this paper, a robotic hand was modelled and simulated using virtual prototyping technology. The 3-d model was developed using CAD software and imported to ADAMS for the simulation purpose. The mathematical analyses were carried out in MATLAB and the results were verified with those of the simulation [14]. A co-simulation-based control strategy was developed in order to impart smooth movement to the hand. The results obtained from theoretical calculations were consistent with those of the simulation, hence, validation the proposed methodology. The advantage of this kind of VP technology is that, a huge amount of data can be collected in a very short period of time. Therefore, a large number of hit and trials can be conducted before the development of physical prototype hence, reducing material wastage and tediousness of the process. Moreover, the material, sensor and actuator selection become easier based on the obtained results. As for further scope is concerned, all these mathematical analyses will be of immense help in developing the under actuated model of the hand.

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# Performance Analysis of LDPC Decoding Techniques

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## ABSTRACT

*Low density parity checking codes (LDPC) are one of the most important issues in coding theory at present. LDPC-code are a type of linear-block LDPC-codes. Channel coding might be considered as the finest conversant and most potent components of cellular communications systems, that was employed for transmitting errors corrections imposed by noise, fading and interfering. LDPC-codes are advanced coding gain, i.e., new area in coding. the performances of LDPC-code are similar to the Shannon-limiting, this led to the usage of decoding in several applications in digital communications systems, like DVB-S2 and WLAN802.1..This paper aims to know what is LDPC,what its application and introduce encoding algorithms that gives rise to a linear encoding time and also show that the regular and irregular LDPC performance and also introduce different methods for decoding LDPC. I discuss in detail LDPC decoding algorithm: bit flipping algorithm, as a type from hard decision .belief propagation algorithm, sum product algorithm and minimum sum algorithm as examples from soft decision .I expect that at least some students or researchers involved in researching LDPC codes would find this paper helpful.*

***Keywords: Low Density Parity Check Code LDPC, Parity Check Matrix H.***

## I. INTRODUCTION

This is One of the newest subjects in coding theory today is low density parity-check codes. a class of linear block LDPC codes is the Low-density parity-check (LDPC) codes. Channel coding can be seen as the best known and most effective component of cellular communication systems used to correct noise, interference and fading transmission errors. Low-Density Parity-Check (LDPC) codes are a greater gain in coding, i.e. a new coding area. The performance of LDPC code is restricted to the Shannon limit, making decoding very desirable for many digital communication systems applications, such as DVB-S2 and WLAN802.11.in this paper we are intended to attempt to discuss the following, such as What are LDPC codes? So why do we take an interest in them? and H0w, are they functioning? Humanity has been engaged in discovering and understanding the World since the dawn of time. The need for higher-speed wireless communication is likely to continue for the near future .The channel settings can suffer as interference, noise and fading as a message transfer. from the transmitter to the receiver.

This creates signal errors that make its recovery at the receiver almost unlikely. Interference, multi-path, and time variation are inherent features of wireless channels that make it difficult to reach, differences between LDPC codes and other codes: The big difference is the sparseness of the parity check matrix, Besides the sparseness, the other difference between LDPC codes and classic block codes is the encoding technique. Classic block codes are generally decoded with Maximum likelihood (ML) decoding algorithms however are generally short and algebraically designed to reduce complexity. LDPC codes are decoded iteratively using a graphical representation of their parity-check matrix, so they are designed with the properties of H as a focus.[4] high data rates on these channels. This problem becomes even more challenging if we Considering the practical need for implementation of low-complexity and low-power systems, the need to find effective solutions to the above problem has generated a great deal of research on wireless communication systems in recent years. Low-density parity-check (LDPC) codes can closely approach the Shannon limit capacity in channel coding theory and become one of the most promising channel codes in the world of error control coding. The reliability of error-correcting codes (ECCs) that approach the Shannon limit. Several approaches have been developed to assist the receiver recover the original signal. There really are two types of techniques for correcting errors, ARQ (Automatic Repeat Request) and FEC (Forward Correction of Error). In ARQ, re-sending is a request when the receiver discovers an error in the received information. In several cases, it is not possible to re-send data, FEC If redundant bits are added to the data, these redundant bits really had no new information, but are later used to identify and correct the error according to redundant bits called parity bits [1]. In the irregular structure of the LDPC, the framework gives rise to ensembles that are not possible. In LDPC designs, various new characteristics can be introduced and new constraints brought to bear. This framework has already been used to generate LDPC codes that perform better than traditional irregular LDPC codes over standard channels such as the AWGN channel, particularly for short block lengths, while necessitating lower complexity. It was used to adapt an LDPC design to the structure of a turbo equaliser receiver, achieving significant gains[2]. The framework produces very low high performance codes and high rate codes with low error floors. [3]

## II. CONTEXT DETAILS

We are just going to focus exclusively on binary linear codes. The binary linear code C of block length n is a vector space $F_2^n$ where $F_2 = \{0, 1\}$ is the field with two elements. The rate of $C$, denoted by $R(C)$, equals to $\frac{k}{n}$ where $k$ is the dimension of $C$ (as a vector space over $F_2$); such a code is also referred to as an $[n, k]$ code. Being a linear subspace of dimension $k$, the code $C$ can be described as the core of a matrix $H \in F_2^{(n-k)\times n}$, so that $C = \{H\}$, where $c = 0$ (codewords $c$ are considered column vectors for this description). The matrix $H$ is called the parity check matrix of the code $C$. In general, any choice of $H$ whose rows form a basis of the dual space $C \Vdash \{x_c^t = 0\}, \forall c \in C$, Well, that describes the same code.

Of particular interest to us here are codes that recognize a sparse parity check matrix. In particular, we will study the Low-Density Parity Check (LDPC) have been used.introduced and studied in Gallagher's Excellent work [5].

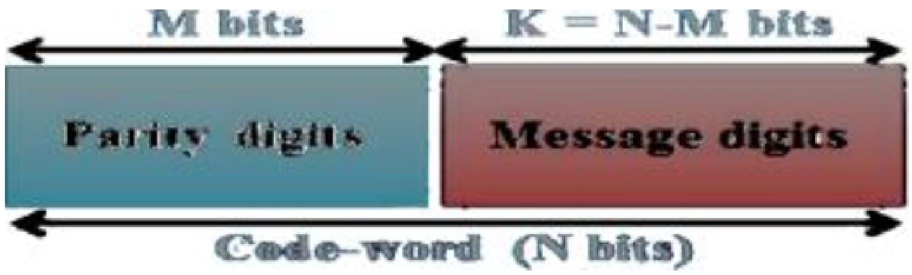


**Fig. 1 General Representation Of Block Code Codes[6].**

**A. Definition of parity Check code.**

LDPC codes are described by a parity check matrix all of whose rows and columns have at most a fixed constant number of 1's (the constant is independent of n). A convenient way to describe an LDPC code is in terms of its factor graph. This is a natural bipartite graph defined as follows. On the left side are n vertices, called variable nodes, one for each codeword position. On the right are m = n - k vertices, called check nodes, one for each parity check (row of the parity check matrix). A test node is adjacent to the corresponding codeword symbols of all variable nodes in this parity check. The parity control matrix of the code, in other words, is exactly the bipartite adjacency matrix of the factor graph. Regular LDPC codes are a special class of LDPC codes, and the factor graph is both left-regular and right-regular. The model originally studied by Gallagher[6], and also in the works of Mackay and Neal[7, 8] and Sipser and Spielman, were in fact the regular LDPC codes that ignited the revival of interest in LDPC codes after more than 30 years given that Gallagher's LDPC codes, based on non-regular graphs, called irregular LDPC codes, came to popularity beginning in the work of Luby et al [9, 10] (One of the major conceptual strides made in these works was exploring codes based on irregular graphs). Later in the article, we will return to this aspect. (3,6)-regular LDPC codes where variable nodes have degree 3 and test nodes have degree 6 are the typical choice of regular LDPC codes (with a rate of 1⁄2) [11].

**III. CHANNEL CODING**

In the wireless communication system, because of channel noise, the signal bearing information produced by the transmitter can not be interpreted correctly by the receiver. The design of a good communication system would decrease the possibility of error in the received signal by allowing the transmitting capacity and usable channel bandwidth to be optimally exploited, while retaining sufficient system complexity. Fig. 2 is a block diagram with various functional representations[12].

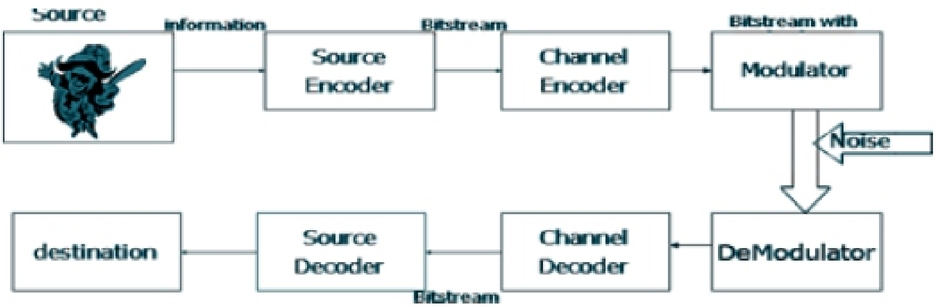


**Fig. 2 show that blocks in the communication system [13].**

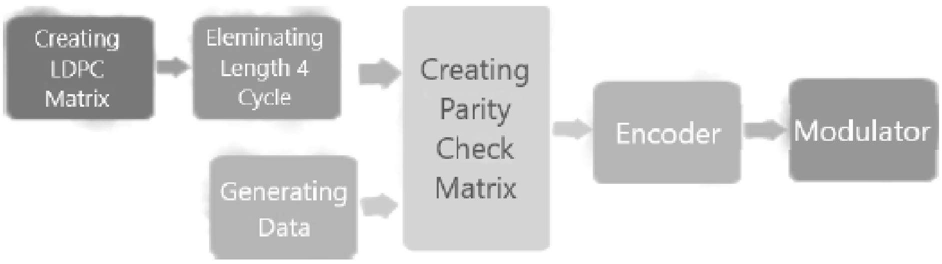


**Fig. 3 is a block diagram with various functional representations[14].**

## IV. SHANNON'S CHANNEL CAPACITY THEOREM

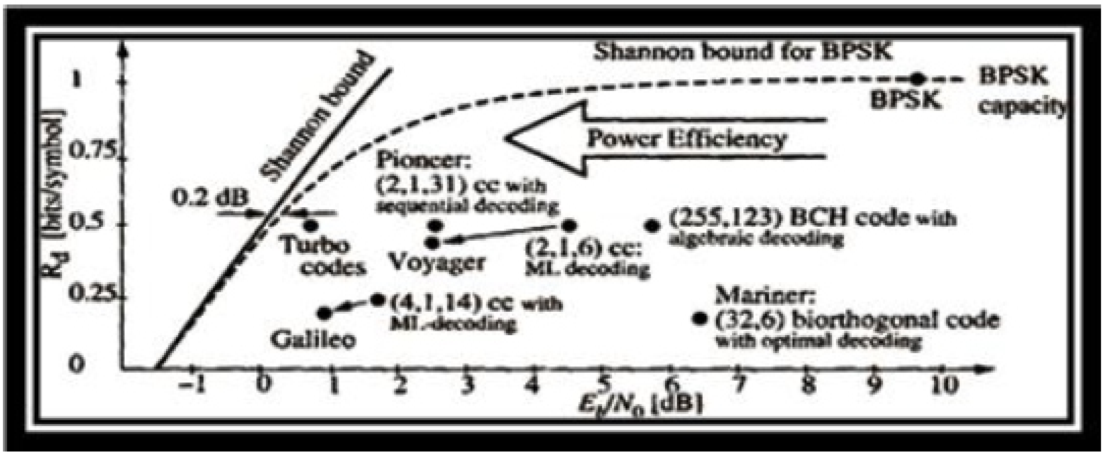


**Fig. 4 show that LDPC code close to Shannon limit[15].**

One of the foremost important people that made great contributions to modern communications, Shannon, an American mathematician put ahead channel capacity in 1948., he figured out that Channel capacity refers to the maximum transmission rate for a particular channel, which means that for every bit error rate, efficient communication can be achieved when the transmission rate is equal to or lower than this maximum rate. On the other hand regardless what kind of transceivers are used the efficiency of transmission can not be assured at a higher transmission rate. This concept is often referred to as the Shannon theorem. [13]. The Shannon channel coding theorem in information theory is known to have encouraged the improvement of error control codes. It states that all the data rates $R_b$ less than the channel capacity C less than the channel capacity $P_e$, where w is given by the Shannon-Hartley formula.[14].

$$C = W \times log_2\left(1 + \frac{P}{N_0 W}\right)$$
$$\frac{C}{W} = \left(1 + \frac{E_b}{N_0}\frac{R_s}{W}\right)\ bits \qquad (1)$$

where,

$C =$ channel capacity, bits/sec,

$W =$ transmission bandwidth, hertz,

$P = E_b R_S =$ signal power, watts,

$N_0 =$ single-sided noise power spectral density, watts/hertz,

$E_b =$ energy per bit of the received signal, joules, and

$R_S =$ source data rate, bits/sec.[15]

## V. PRELIMINARIES

**Coding:** The transfer of data to another type for some reason.

**Source Coding:** The goal is to reduce the redundancy of data in the.

**Channel Coding:** The goal is to overcome channel noise bits in the bit stream of the sender to create a codeword..

**Encoder and Decoder:**
The encoder adds that the redundant bits are used by the decoder to detect and/or correct as many bit errors as the basic error control code allows.

**Modulator and Demodulator:** The modulator converts the digital output of the encoder into a channel-specific format that is normally analogue (e.g., a telephone channel). In the presence of noise, the demodulator tries to retrieve the correct channel symbol. The decoder tries to correct any errors that occur when the wrong symbol is chosen.

**Bit-Error-Rate (BER):**
The probability of an error in bits. For an error management code, this is always the figure of merit. We want to keep this number small, less than 10-4 usually. The bit-error rate is a useful measure of system quality on an independent error channel, but on bursty or dependent error channels, it has little meaning. Burst Errors: Errors that are not independent. For example, channels with deep fades experience errors that occur in bursts. Because the fades make consecutive bits more likely to be in error, the errors are usually considered dependent rather than independent. In contrast to independent-error channels, burst-error channels have memory.[16]

## VI. HISTORY OF LOW-DENSITY PARITY CHECK CODES
In 1948, Shannon published his famous paper on the capacity of channels with noise. In 1963, Robert Gallagher wrote his Ph.D. dissertation "Low Density Parity Check Codes". He introduced LDPC codes, analyzed them, and gave some decoding algorithms Because computers at that time were not very powerful, he could not verify that his codes could approach capacity. In 1982, Michael Tanner considered Gallagher's LDPC codes, and his own structured codes. He introduced the notion of using bipartite graph, sometimes called a Tanner graph. In 1993, Turbo Codes were introduced. They exceeded the performance of all known codes, and had low decoding complexity. In 1995,interest was renewed in Gallagher's LDPC codes, led by David MacKay and many others. It was shown that LDPC codes can essentially achieve Shannon Capacity on AWGN and Binary Erasure Channels [17].

### i . Form of the System
The LDPC system model consists of transmitter, AWGN channel and a receiver


**Fig. 5 Form of the system[16].**

### ii .Transmitter of LDPC system
The transmitter of the LDPC system consists of creating LDPC matrix, eliminating length-4 cycle, generating parity check matrix using LU factorization on LDPC matrix. The generated data is then encoded using the parity check matrix. BPSK technique is used for modulation.[18]

**AWGN Channel**

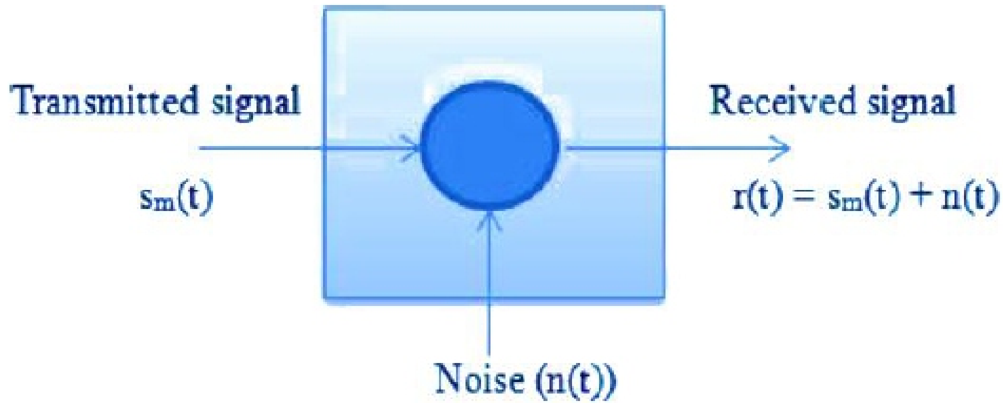


**Fig. 6 show that AWGN additive white Gaussian noise channel[19].**

High data rate communication over additive white Gaussian noise channel (AWGN) is limited by noise. The received signal in the interval $0 \leq t \leq T$ may be expressed as $r(t) = (t) + n(t)$, where $n(t)$ denotes the sample function of AWGN process with power (spectral density)[19].

**VII. LITERATURE SURVEY**

Significant research the reliability of the systems was once begun for a long time ago. In the preceding work, researchers tried to decrease the design complexity, power consumption and increase the speed of LDPC decoder.In2020, by publishing a paper entitled Joint optimization of interleaving and LDPC decoding for burst errors in PON systems, Lei Zhang et al. improved decoding performance by explaining that the proposed scheme is more characteristic at greater lengths of burst-error. With a burst-error length of 1500 and a pre-BER of 0.0243, the post-BER values of 8×2400 block interleaves, random interleaves and convolutionary interleaves are $9.5117\times10^{-5}$,$2.4372\times10^{-5}$ and $1.9461\times10^{-5}$, respectively. On the other hand, our proposed scheme has two orders of magnitude with better post-BER performance ($1,5672\times 10^{-7}$). The simulation results therefore justify our design rule, which achieves a common optimization of interleaving. and LDPC decoding, which can significantly improve the performance of decoding in PON systems that deploy LDPC codes.[20]. Hossein Gharaee and et al presented "A High-throughput FPGA Implementation of Quasi-Cyclic LDPC Decoder" in their work in 2017. In their papers, an FPGA implementation of a partial-parallel QC-LDPC decoder was proposed based on the sum-product algorithm. This is a modified version of the TPMP1 algorithm to increase the number of clock cycles, cost efficiency and power consumption. The results indicate that by implementing the sum product algorithm in the proposed time schedule, this decoder showed maximum throughput with lower power consumption and area.[24]

.As of 2018. Ahmed Abdel-Mouleh, introducing thesis is titled "Non-binary LDPC codes associated with high-order modulations," which he devoted to exploring the relationship of non-binary LDPC codes (NB-LDPC), with high-order modulations. And aims to increase the spectral performance of future wireless communication systems. Their approach seeks to take full advantage of the direct correlation between NB-LDPC codes with modulation constellations of the same cardinality over a Galois field. The second contribution concerns a new method for designing an advanced CM communication scheme for high-spectral efficiency. Mutual optimization of the NB-LDPCcode and M-QAM modulation, the benefit of using the same order for both (q=M), is the key concept behind the technical method. This approach is different from what is subsequently achieved, where the codes and modulation of the NB-LDPC are optimised in a disjointed way[26].In 2018, a novel was proposed by Albashir Adel Youssef and others in which comprehensive performance evaluations of different LDPC decoding algorithms are used to enhance communication and decrease the complexity of implants for WBAN channel implants. In the BER, prominence has been shown by the proposed low-complex LDPC hybrid decoding algorithm, decoding iterations, hardware complexity, number of operations, decoder convergence, decoder throughput, statistical properties and decoding time. Because of the use of the lowest number of iterations necessary, hardware complexity, decoder convergence, decoder throughput, the proposed algorithm achieved the lowest level of complexity, Besides that, the In particular, modest LDPC matrices and Bottommost E b = N 0 S were occupied with the minimum number of operations. In comparison, the proposed algorithm, similar to MIERRWBF and BMIERRWBF, achieved a lower decoding time, performed a progressive number of decoding operations and obtained the highest resulting efficiency among all algorithms developed. Furthermore, relative to other algorithms, the proposed algorithm achieved the fastest convergence and conducted a non-parallel statistical analysis while retaining the same statistical analysis. Preserving comparable decoding parameters[27].

## VIII. WHY LDPC CODES RAISE OUR ATTENTIONS?

How they are decoded is the main difference between classical block codes and LDPC codes. Classical block codes, such as decoding algorithms, are generally decoded with ML and are therefore generally short and algebraically constructed to make this role less complex. However, using a graphical representation of their parity-check matrix, LDPC codes are iteratively decoded and are therefore designed with the properties of H as a priority and appear to have better block error performance and better performance performance on bursty channels. They are m0re suited for high rates and can really be designed for roughly any block rate and length. (The rate of turbo codes is typically modified by way of a puncturing method that needs an additional design step in comparison.), Their error level tends to occur at a lower rate. Interleaves may not be needed for the encoder and decoder. For channel collection, a single LDPC code may be universally sufficient. There are iterative LDPC decoding algorithms that are simple to implement, have moderate complexity (which scales linearly with the block length), and are parallel to hardware. In particular, LDPC decoding seems to be less complex than turbo decoding using the BCJR algorithm using the Credential Propagation (Sum Product) algorithm. Inherently, LDPC decoders check if a codeword satisfying the check equations has been found and otherwise announce a decoding failure (on the other hand, turbo decoders typically need to perform additional operations to calculate a stop criterion, and even then it is not clear if the result of decoding corresponds to a codeword satisfying the check equations). [28].The LDPC code decoding method is an iterative process with low computational complexity based on a sparse matrix, while the parallel structure provides a chance to implement hardware. Since it is simple to create the LDPC code rate, system optimization with a versatile and self-adapted coding system is possible. When it comes to high-speed data transfer or high-performance applications, LDPC performs better compared with Turbo LDPC codes. Another benefit of LDPC is low error flooring, which enables low-bit error. rate (BER) applications to operate, such as wire communication, deep space communication and storage media, [29].

## iii . LDPC APPLICATIONS

Today, because of its superior decoding performance as well as the benefits associated with hardware implementations, such as low-cost high-throughput capabilities and power efficiency, LDPC codes have achieved widespread applications in modern communication systems. As a consequence, other well-known FEC systems are increasingly being replaced by LDPC codes. Several recent communication standards have been introduced, such as 802.11n (Wi-Fi), 802.11ad (WiGig, 802.16e

(WiMAX), 802.15.3c (WPAN) and seconds, for example. Irregular LDPC codes are used in the high definition satellite television (HDTV) standard, which is known as the Digital Video Broadcasting (DVB-S2) transmission system standard. From optical networks to digital storage, DVB-S2 is considered for a wide range of applications. LDPC codes have also been proposed as a possible candidate for a 5 G cellular system[11]. The LDPC code has a wide range of applications, such as satellite communications (DVB-S2), storage devices, optical communications, Wi-Fi and WiMAX mobile[22], and is selected as the channel code type for the mobile 5 G data channel transmission system[23]

**iv . LDPC IMPROVEMENT CODES**

one of the forward error correction codes that Robert Gallagher invented in 1960 is LDPC. Since the difficulty of implementing hardware at that time was overlooked until MacKay and Neal rediscovered it in 1996.[34] It was considered a code for capacity-approaching. The phrase low-density comes from the matrix of parity check, in which the number of zeroes, also called Gallagher codes, is much smaller than the number of zeroes. This concerns one of the kinds of block codes in which there are K information bits encoded and decoded by themselves in a message separated into two blocks[33]. There are two matrices in the LDPC code, the generator matrix (G-matrix) on the encoder and the parity matrix (H-matrix) on the encoder.

**v . LDPC CODES TYPES**

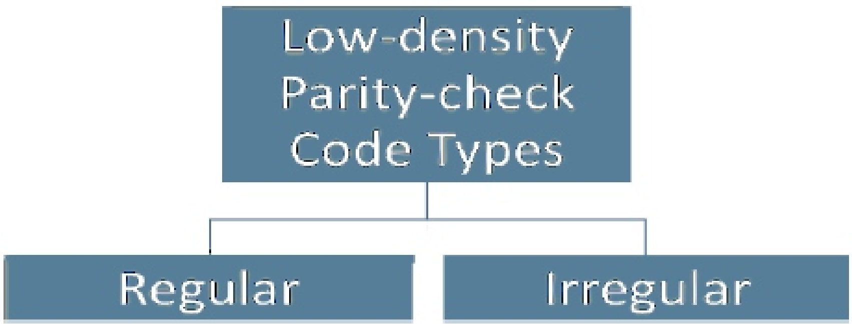


**Fig. 7 show that types of LDPC codes.**

If $w_c$ is constant for every column, $w_r$ is constant for every row and $w_r$ is constant for every row, the LDPC code is said to be regular. It is called irregular an LDPC which is not regular.

Example.1.

A regular parity-check matrix for the code in with $\boldsymbol{w_c} = \mathbf{2}, \boldsymbol{w_r} = \mathbf{3}$, which satisfies is

$$\mathbf{H} = \begin{pmatrix} 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 & 1 \end{pmatrix}$$

**Definition LDPC Codes**

An LDPC code is a linear block code defined by a (M, N) sparse parity-check matrix denoted by H. consider a linear (N, K) block code C, which H has N rows $r_n$, wheren = 0, ......, N - 1 and M = N - K linearly independent columns $h_m$, where m = 0, ..... N - K - 1. As their name suggests, sparse or low-density means that the paritycheck matrix contains only few 1s in comparison to the amount of 0s. This sparseness of H is essential for iterative decoding complexity, which only increases linearly with the length of the code[7]. The other type is the irregular LDPC code which do not have uniform row and column weights. Irregular LDPC codes are the one in which H The density is poor, but there is no constant number of 1s in any row or column.

**Example .2. of irregular LDPC code**

$$\begin{pmatrix} 0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 \\ 1 & 0 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 1 & 0 \end{pmatrix}$$

**Matrix shown that irregular LDPCcode**

## IX. REPRESENTATION OF THE LDPC CODE

No analytical (algebraic or geometric) approach has been used to design such codes, while LDPC codes have been shown to achieve excellent efficiency. Only one class of pseudo-random LDPC codes was given by Gallagher . Strong LDPC codes, particularly long codes, that have been found are largely computer-generated. Due to the absence of code structure, such as cyclic or quasi-cyclic, the encoding of these large computers generated by LDPC codes is very complex. structure. In addition, their minimum distances are either poor or difficult to determine[17].There,essentially, are two different possibilities to represent LDPC codes. Like all linear block codes, they can To be identified by matrices. A graphical representation is the second possibility. These two representations are completely identical, and based on the types of simplification it brings to solve the problem, we choose one or the other.

### A1 .Matrix Representation

$$\begin{pmatrix} 1 & 1 & 0 & 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 1 & 0 & 1 & 0 & 1 & 0 & 1 \end{pmatrix}$$

Each column represents a coded bit in the check matrix H, while each row equates to a check sum. The number of non-zero elements for each column is known as column weight (wc), and the number of non-zero elements for each row (wr) is also referred to as row weight. The matrix of its size M-N) with M = N-K. More precisely, in the form of a linear system, the parity check matrix defines the relation between the code word symbols, i.e. Hx=0, 0. Gallager claimed that this matrix ought to have a limited number of non-LDPC codes when implementing LDPC codes. There are zero elements. A small proportion of symbols would provide the low density matrix of each interaction. In the case of a hierarchical code, the symbol corresponds to every column, The first column K corresponds to symbols of information, and the last column N K corresponds to symbols of redundancy. The LDPC code with N=1⁄4 8 and K=1⁄4 4 is defined by the parity matrix, for example [ 27] .

### A 2. Graphical Representation

The second representation of the LDPC codes is a bipartite graph, also referred to as the Tanner graph. The graph is bipartite if there are two sets of vertical nodes U and V and a set of edges such that each edge connects the node U with the node V. You can describe the LDPC code from a Tanner graph whose node set V (variable nodes) represents the codeword symbols and all the correct nodes, denoted (consensus nodes).. The symbol sequence would then be a valid code word if and only if the number of symbols corresponding to the vector nodes for each node limit is zero. The Tanner graph with the code for the LDPC is [29].

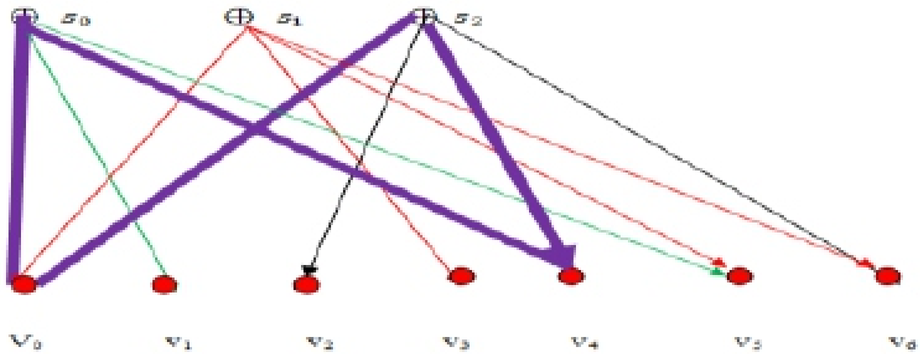

**Fig. 8 shown that Tanner graph**

Tanner considered LDPC codes and showed how the so-called bipartite graph, also known as the Tanner graph, could be effectively represented, providing a complete representation of the code and helping to understand the decoding algorithm[28].

**•Encoding**

Usually, LDPC codes are constructed by creating a sparse check matrix H first and then evaluating the corresponding generator matrix G. The complexity of encoding through the standard relationship c = Gu in block length N is not sparse, but there are different types of LDPC codes which have a deterministic structure that reduces the complexity of encoding.based on finite geometries that lead to cyclic or quasi-cyclic LDPC codes that can be encoded using Shift registry circuits, such as some LDPC code designs, and a deterministic str, on the other hand, allows efficient encoding[32].

## X. CONSTRUCTION METHODS FOR LDPC CODE

Based on construction methods, the LDPC codes can also be divided into two other classifications. In the absence of a deterministic structure, the encoding complexity can still be significantly decreased by an encoding process based not on the matrix of the G generator but directly on the matrix of the H check.

### B 1. Gallagher's LDPC code construction

The technique proposed the following random construction of a regular LDPCcode parameters are chosen such that $N = p\omega_c$ and $M = p\omega_r$ withan integer factor $p$, so that $N/\omega_c = M/\omega_r = p$ .The density of $H$ follows from $\rho = \omega_r/M = 1/p$. Thus. the code is an LDPC code if $p$ It is picked to be big enough. Then, the $N \times M$ check matrix $H$ isconstructed as a block-rowmatrixcomposed of $\omega_r \geq 3$ blocks $H_i$, where $i = 1, \dots, \omega_r$ of dimension $N \times p$ each, i.e., $(H_1, \dots, H_{\omega_r})$

Example

Given the regular (Gallagher) LDPC code parameters $N = 20, k = 5, \omega_r = 4$ and $\omega_c = 3$ , the resultant $H$ is given by the following $H$ matrix

H=

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |

Mostly for large block lengths, the ability of LDPC codes to perform near the Shannon limit of a channel exists.. For example, Simulations have been carried out throughout the system. $0.0045\ dB$ of the Shannon limit at a biterror rate of $10^{-6}$ with a block length of.[25].

**B 2.Mac-Kay's Construction Technique**

$$H = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 \end{bmatrix}$$

Suggests that the encoding should be performed by using the generator matrix G obtained through Gaussian elimination from H. This approach is not efficient because even though the Parity-Check matrix is sparse, the generator matrix is not generally effective. The encoding complexity of the long block length codes generated in this way will therefore be high.[26] In this approach, columns in H are generated from left to right until the whole check matrix is created. Column weight can be ensured to meet the demand as a premise and the location of non-zero elements is selected randomly between rows as long as the overall allocated row weight is not exceeded. reset of H or cancelation and reset of some rows from right to left in the matrix occurs when the row weight cannot meet requirements when setting the last column.[27]

**B 3 .Cyclic Shift Matrices-based algebraic construction**

A basic algebraic structure of the check matrix H with a column weight $\omega_c$ and row weight is $\omega_r$ as follows for an arbitrary $p \geq (\omega_c - 1)(\omega_r - 1) + 1$ and an arbitrary $J \epsilon \{0, \ldots, p-1\}$ ,consider $p \times p$ cyclic shift matrix $J_J$ that is obtainedby cyclically shiftingeach column ofthe $p \times p$ identity matrix $I$ down by $J$ positions, for example, for

$$J_1 = \begin{pmatrix} 0 & 0 & 0 & \cdots & 0 & 1 \\ 1 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 1 & 0 & \cdots & 0 & 0 \\ 0 & 0 & 1 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & 1 & 0 \end{pmatrix}$$

Note that $J_1 = J_1^J$ then, the check matrix constructed as

$$H = \begin{pmatrix} I & I & I & \cdots & I \\ I & J_2 & J_4 & \cdots & J_{2(\omega r-1)} \\ I & J_3 & J_6 & \cdots & J_{3(\omega r-1)} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ I & J_{\omega c-1} & J_{2(\omega c-1)} & \cdots & J_{(\omega c-1)(\omega r-1)} \end{pmatrix}$$

## XI. DECODING METHODS

The near-capacity performance of low-density parity-check codes was first demonstrated with efficient decoding algorithms like min-sum (MS) and sum-product (SP). These two decoding algorithms take advantage of the sparseness of the parity-check matrices of LDPC codes, since the complexity of the MS and SP algorithms scales in proportion to the number of binary 1s in the parity-check matrix. However, due to the sub-optimality of the MS and SP decoders, new decoding algorithms for LDPC codes have been created along with variations of the SP and MS decoders in an attempt to improve their performance.[19].With more or less the same iterative decoding algorithm, distinct authors come up separately. They call it various names: the algorithm of the sum-product, the algorithm of the propagation of beliefs, and the algorithm of message passing. This algorithm has two derivations: hard-decision and soft-decision schemes.[15] Several decoding approaches have been suggested based on iterative decoding, including high-parallel and low-parallel degrees. For high-parallel decoders, check node l units, variable node units and interconnects are integrated in a single chip. Both messages are measured in parallel and each decoding operation is done in one clock cycle.there is a short decoding delay and quick throughput for decoders with high parallelism, but they have a large silicon region. Low-parallel decoders, on the other hand, need fewer processing units and higher-density memories instead of separate registers, so the area is smaller and it provides lower throughput[14].

## XII. BASICS OF ITERATIVE DECODING

In order to converge towards a global solution, the idea behind iterative principles is to solve a global problem by splitting it into smaller problems that are easier to solve and iterate between them. The basic building blocks and principles of iterative decoding systems that will be used in this thesis are introduced in this section. We present, first of all the channel models and their unified definition. Instead, part codes and the definition of concatenated codes was applied to establish successful codes.codes that are iterative algorithms that can be decoded. Finally, turbo codes and low-density parity-check (LDPC) codes, the most popular iterative decoding codes, are described.[14].

### I. Hard Decision Decoding

- Simple decoder construction.
- Input values are not considering the channel Information.
- Bit flipping algorithms.
- Faster convergence with significant impact on error correcting characteristics

### II. Soft Decision Decoding

- Complicated decoder construction
- Channel information is considered in decoding process
- Message passing algorithms Slow converging, but more powerful methods of decoding.[16].

### a) Bit-flipping Decoding

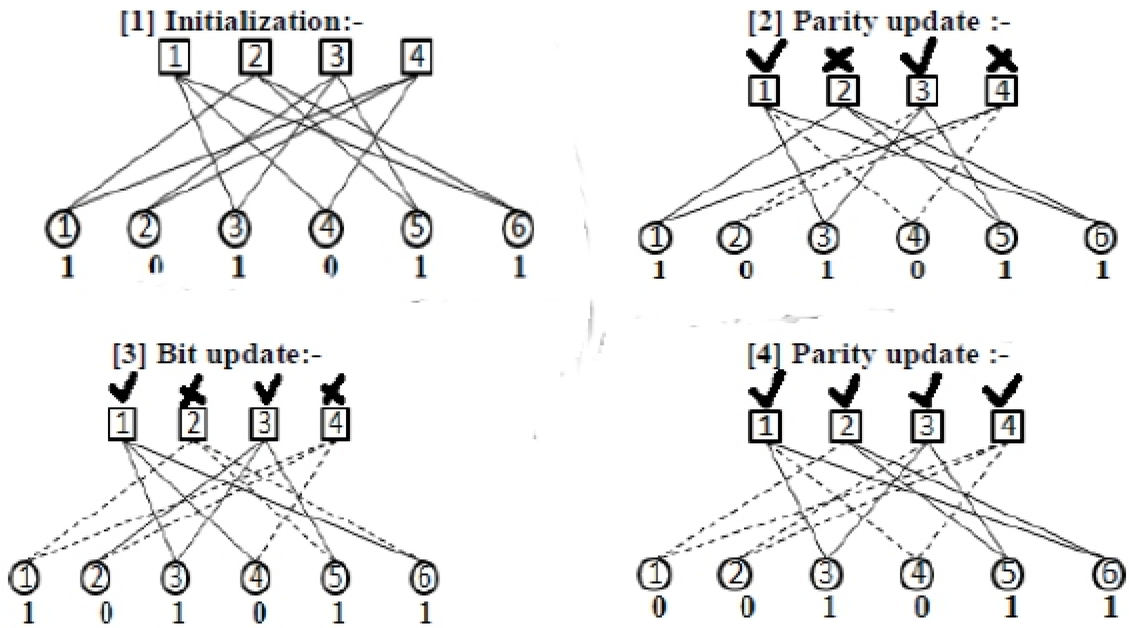


**Fig. 9 show that bit _flipping**

For every bit received, Bit Flipping is based on a hard start decision[28]. The hard binary decision is taken by the detector on each obtained bit and transferred to another decoder. The message is passed from the nodes of the code tanner graph during bit flipping. Each Bit Node sends messages to each check node. The message for each bit will be either 0 or 1. There are three steps for Bit Flipping to take. Here is a thorough analysis of the algorithm for Bit flipping[19].

An example H Matrix shows this process step by step.

**Step1** InitializationEach bit is assigned a value.
All data is sent to the linked check nodes after this.
3, 4 and 6 check nodes are linked to the bit node 1.
The check nodes 1, 5 and 6 are joined to the bit node 2.
The check nodes 2, 3 and 5 are related to the bit node 3.
The check nodes 1, 2 and 4 are connected to bit node 4.
Node Check receives bit values sent by bit nodes.

Updating Step2Parity. This time, Step2 will be repeated again and again until all the equations for parity tests are satisfied. The algorithm will terminate when all the parity check equations are satisfied, and the decoded final value will be 001011.

**b) sum-product algorithm (SPA)**

The sum-product algorithm is a message-passing algorithm for a soft decision. It is similar to the bit-flipping algorithm mentioned in the previous section, but now with probabilities for messages representing any decision (check met, or bit value equal to 1). The sum-product algorithm is a soft decision algorithm that accepts the probability of each received bit as input, while bit-flipping decoding accepts an initial hard decision on the received bits as input.The a priori probabilities for the obtained bits are called the input bit probabilities because before running the LDPC encoder, they were known in advance[33]. a posteriori probability is referred to as the bit probabilities returned by the decoder. These probabilities are expressed as log-likelihood ratios in the case of sum-product decoding.The sum-product algorithm (SPA) asymptotically achieves the near-capacity performance The sum-product algorithm uses the soft obtained signal, which again is important when using continuous-output channels. Although the sum-product algorithm (SPAcomputational )'s complexity is very high. In practise it is difficult to implement the Sum-Product Algorithm for decoding LDPC codes, since it requires nonlinear functions and multiplications. Instead of taking the computational complexity of the SPA, to decrease $L(r_{ij})$ An approximation of that is taken, which simplifies the check node update law. The Min-Sum algorithm is known as this modified version of SPA.

**c) Min-sum algorithm:**

To a the complexity of the standard SPA at the cost of a noticeable degradation of decoding, a mini-sum algorithm (MSA) has been proposed which replaces non-linear control node operation with a single minimum operation. performance. In the min-sum algorithm, the update rule for the variable node is the same as the sum-product. algorithm, but the update rule at a check node c is simplified by taking $|q_{i,j}|$ term instead of $L(r_{ij})$ which is actually the approximation of the latter. The magnitude of $L(r_{ij})$ computed using min-sum approximation is usually To decrease the approximation error, overestimated and correction words are added. When the magnitude of the messages is increased, this approximation becomes more precise. So in later iterations, the output of this algorithm is almost the same as that of the sum-product algorithm when the magnitude of the messages is normally high. The Min-Sum algorithm is less complicated to implement, requiring an additional signal-to-noise ratio of approximately 0.5dB to Achieving the same bit error rate as the Sum-Product algorithm by using a regular transmission LDPC code over just a binary input additive white Gaussian noise (AWGN) channel. The loss of output can be up to 1.0dB for irregular codes. approximately an additional $0.5dB$ of signal-to-nois $\frac{E_b}{N_0}$ atio to achieve the same bit error rate as the Sum-Product algorithm, when using a regular LDPC code for over an additive white Gaussian noise (AWGN) channel with binary input. For irregular codes, the loss in performance can be up to $1.0dB$. .

**Table 1: Difference between Random Method and ALgebraic Method**

| | ALGEBRAIC CONSTRUCTIONS | RANDOM CONSTRUCTIONS |
|---|---|---|
| Performance Large Block Length N>> | Perform less well | Good if the block length N is large |
| Performance Moderate Values of Block Length N<< | Often better | May not be sufficiently good for moderate values of N |
| Structure to Allow Efficient Encoding | Strong structure | Do not have a structure to allow efficient encoding |
| Efficient Encoding | More efficiently than random LDPC | Not efficient encoding |
| Complexity of Decoding | Complexity that grows only linearly with the block length. | Complexity of decoding is a lesser issue because iterative message passing algorithms allow efficient decoding |
| Error Floor | Low error floor | Higher error floor |

## XIII. CONCLUSION

This paper summaries the important concepts regarding Parity-Check Code (LDPC) for low density. It goes into the motivation of LDPC and how it is possible to decode LDPC. Different code modifications, these codes is still attractive for creating powerful codes. error correction code with reasonable complexity. As a class of concatenated codes where LDPC codes are irregular codes with different parameters interacting in parallel or in serial] with or not including interleaves, concatenated binary LDPC codes have been added. While irregular LDPC codes are more efficient than regular codes, there is an error floor and a senior level of irregular LDPC codes. encoding Complexity over regular codes . LDPC codes, based on deep and wealthy theory, are very powerful codes with huge functional possible. major advances in all core aspects of LDPC code design, review and implementation continue to be developed.

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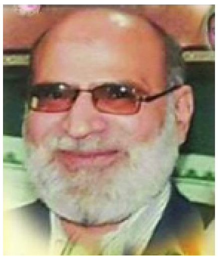

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# Limitations and Advantages in Implementing MALL in the Tertiary ESL Classrooms: A Review

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## A B S T R A C T

*Technology-assisted facilities have taken English Language Teaching (ELT) to a different level where Computer Assisted Language Learning (CALL) has become an indispensable feature of leaning a language. Recently, in the current day context of ELT, both learners and teachers are experiencing a positive shift from CALL to another more efficient platform called Mobile Assisted Language Learning (MALL). This paper explores the fundamentals of MALL and its application in ELT. Moreover, it sheds light on the various advantages and limitations in implementing MALL devices like mobile phones, smartphones, kindles and so on in the regular as well as virtual classroom context. It discusses theories on technology-enabled learning and MALL. The primary focus of this paper is to shed light on the perspective of employing MALL in the language classes at the tertiary level.*

***Keywords: Computer Assisted Language Learning (CALL); Mobile Assisted Language Learning (MALL); Advantages and limitation of MALL; MALL theories; MALL methods***

## I. INTRODUCTION

After its advent into education at the beginning of this century, mobile leaning has rapidly grown into a common modality in the context of English Language Teaching and Learning (ELT&L). It has open doors for many new opportunities in information and communication technology (ICT) for language learning and pedagogical approaches toward ELT & L. Initially, there used to be a common misunderstanding of the term „mobile" in this context that the term„mobile" represents mobile phones alone in the process of teaching and learning. However, mobile learning (ML) is defined as a learning process where the interactions among learners and with the content happen via personal electronic devices which includes handheld computers, MP3 players, notebooks, mobile phones, tablets and so on. According to Mohammadi, E &Shirkamar, I S (2018), mobile-assisted language learning (MALL) is a branch of learning on a mode based on the technology which can be applied in several forms including face-to-face, distant or on-line modes. Similarly, MALL is any form of language learning that takes place at the convenience of the learner in terms of place and time. Gholami, J., & Azarmi, G. (2012) state that the processes of learning and being able to achieve considerable learning experience in, and across, new and ever-changing contexts and learning platforms and most importantly, converting the everyday life-worlds as learning spaces. In MALL, learning happens through any mobile handheld devices such as mobile phones, smartphones, i-pads, phablets and so on(Shield &Kukulsca, 2008).Similarly, ML is the acquisition of any knowledge or skill through using mobile technology, anywhere and anytime (Geddes, 2004). The following section deals with different modalities of using mobile devices in the ELT&L process. It also exploresthe theoretical underpinnings of MALL.

### A. Modalities

MALL brings a tectonic shift from the routine learning strategies to a technology-oriented approach to re-conceptualize the needs of today"s tech-savvy students. Based on the usage of mobile phones, mobile phones have been used in three different modalities:

(I) Asynchronous mobile phone assisted language learning (AMPALL)
(ii) Synchronous mobile phone assisted language learning (SMPALL).
(iii) Teacher moderated synchronous mobile phone assisted language learning (TMSMPLL).

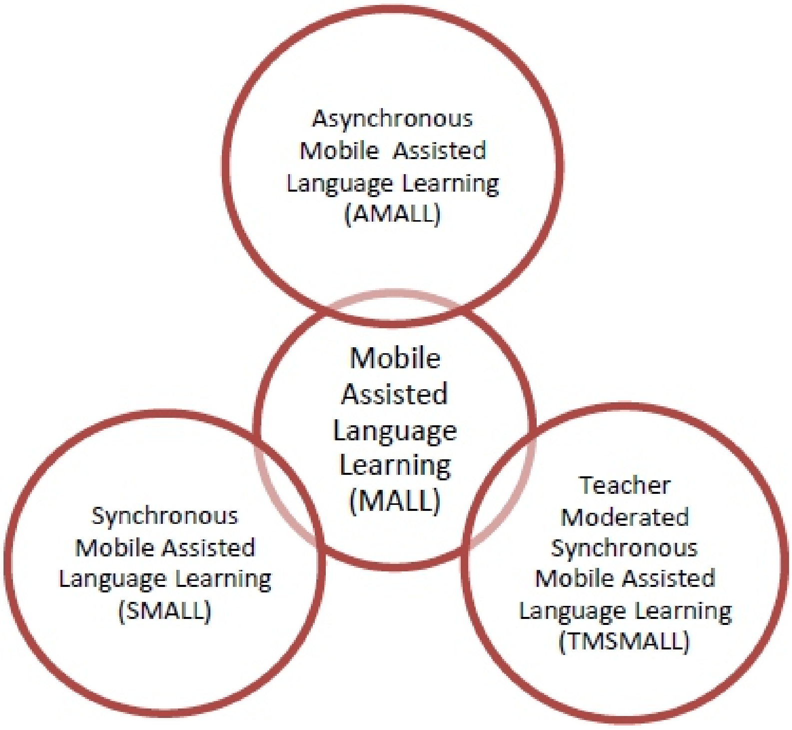


**Figure-I: Three Different Modalities of MALL**

## II. THEORETICAL UNDERPINNING

Theories and models originated from the general theories of learning established such as constructivism, situated learning theories, and so on have been applied to mobile learning and mobile learning pedagogies. The concept of mobile learning deals with the practices that encompass developmental process by simultaneously interlinking individual and social levels of learning (Kutti 1995). This theoretical approach functions as a tool in the process of analyzing mobile learning contexts (Uden 2007). According to the study conducted by Nalliveettil et al., (2016), mobile phones can accelerate students" English language learning abilities.

They have further discussed that the advantages of learning the English language effectively is one of the major causes for students to buy mobile phones and other mobile devices. The availability and accessibility of technology alone will not yield positive results in the teaching-learning process, whereas the user acceptance of technology becomes a prime concern in the process. Moreover, it has been an important field of study for over two decades now (Chuttur 2009). As teachers and students are the prime members of the teaching-learning process, their acceptance of technology as an effective mode of learning becomes a major area of concern. Fred Davis (1985), proposed the Technology Acceptance Model (TAM), where he states three phases: (i) System Features and Capabilities, (ii) User"s Motivation to use the system and (iii) Actual System Use. He further discusses that the system use is a response that can be explained or predicted by user motivation, which, in turn, is directly influenced by an external stimulus consisting of that actual system"s features and capabilities.

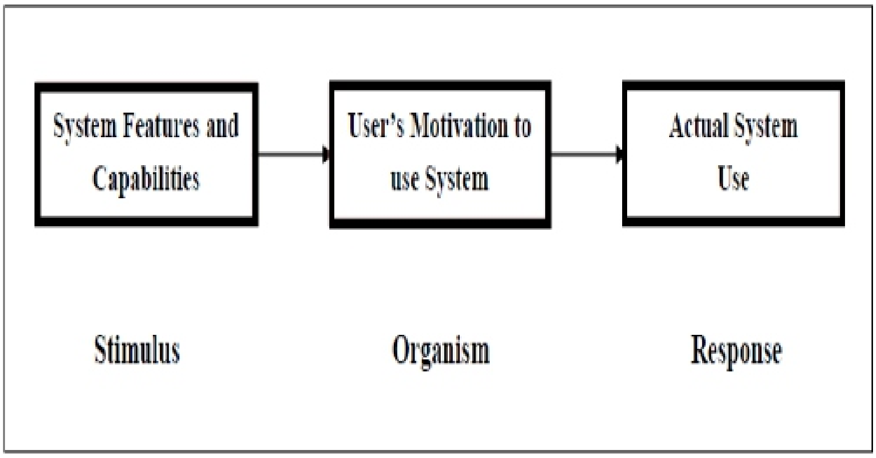


**Figure-II: Technology Acceptance Model (TAM) (Davis F, 1985)**

Venkatesh et al. (2003) further studied TAM and introduced an improved version in the year 2003.

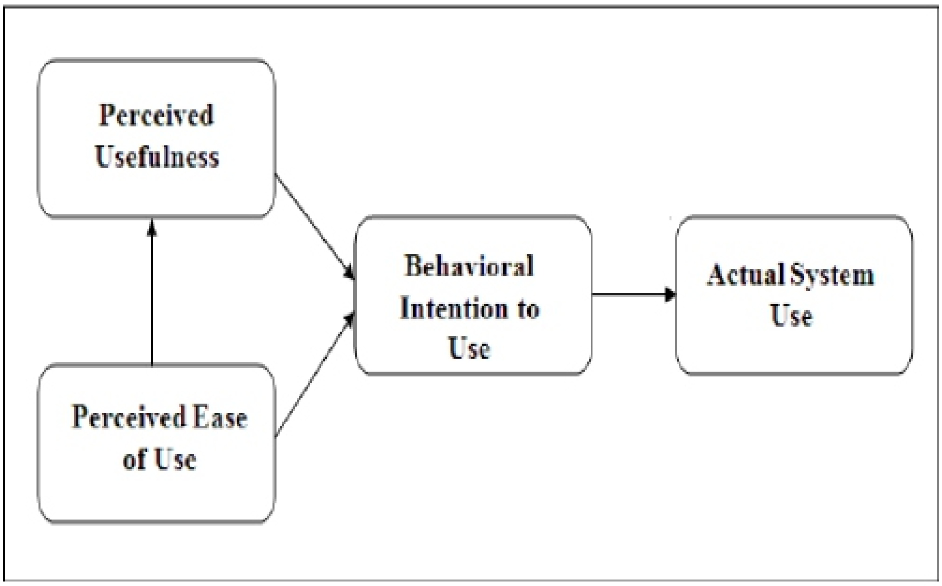


**Figure-III: Technology Acceptance Model (TAM) (Venkatesh et al., 2003)**

Teachers and students believe that a particular system if incorporated into the teaching-learning process would enhance their performance; this degree of belief is known as Perceived usefulness (PU). Similarly, the degree to which they believe using a particular system would be free from effort is known as perceived ease of use (PEOU). Both PU and PEOU contribute to behavioural intention to use (BIU) which is when they intend to use and not out of compulsion, and this complements or results in a positive and effective actual system use (ASU). To identify if the characteristics of learning as a community in a virtual environment and its impact on the teachers and students at the higher education level, Wenger (1998) proposed the e-learning ladder model.

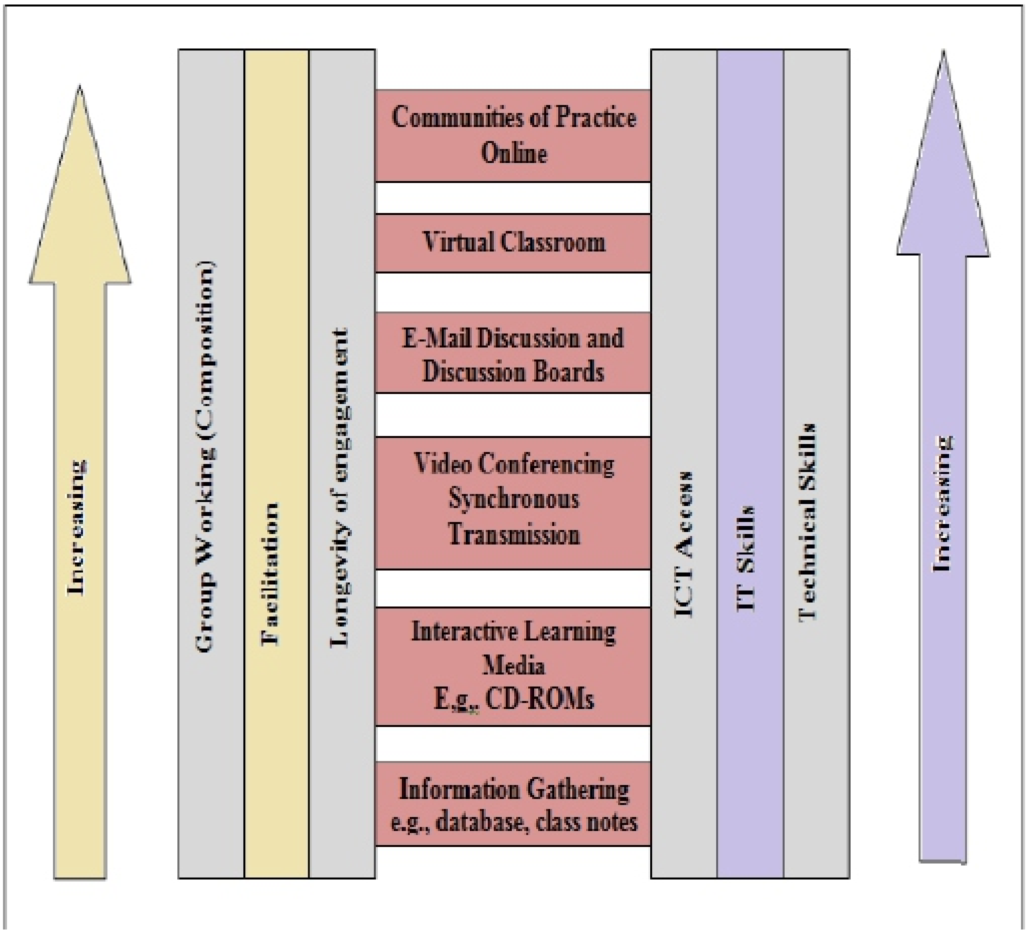


**Figure-IV: The E-Learning Ladder Model**

According to Moule (2006), this model presents a range of approaches starting with an isolated approach to teaching and learning at the bottom „rung" of the learning ladder. This instructivist approach continues until the constructivist or interactive learning approach begins. The is where the teacher plays a vital role in the teaching-learning process. The ladder model presents the positioning of learning from instructivist to constructivist levels.

## III. MAJOR STUDIES ON MALL: A REVIEW

Klopfer et al (2002), on mobile devices, have come out with ideas that help the learner understand the advantages of using these devices in their learning process. Portability of the mobile devices forms one of the greatest advantages. Such devices can be easily taken to different places without any limitations in terms of size or weight. This feature of these devices results in better social interactivity, where sharing of information and engaging in collaborative projects and learning have been made possible. Another major advantage is context sensitivity which enables the learners to gather and respond uniquely to the information on the mobile devices without compromising on space and time. Similarly, connectivity empowers the learners to connect mobile devices to other devices and different networks by creating a shared network. Most importantly, these devices enable the individual learner to customize the learner environment for better output. Based on the Telephone Regulatory Authority of India (TRAI) report 2020, the number of telephone subscribers in India increased from 1,172.44 million at the end of Dec-19 to 1,177.02 million at the end of Jan-20, thereby showing a monthly increase rate of 0.39%. Fig. 5 show the state-wise teledensity of the country.

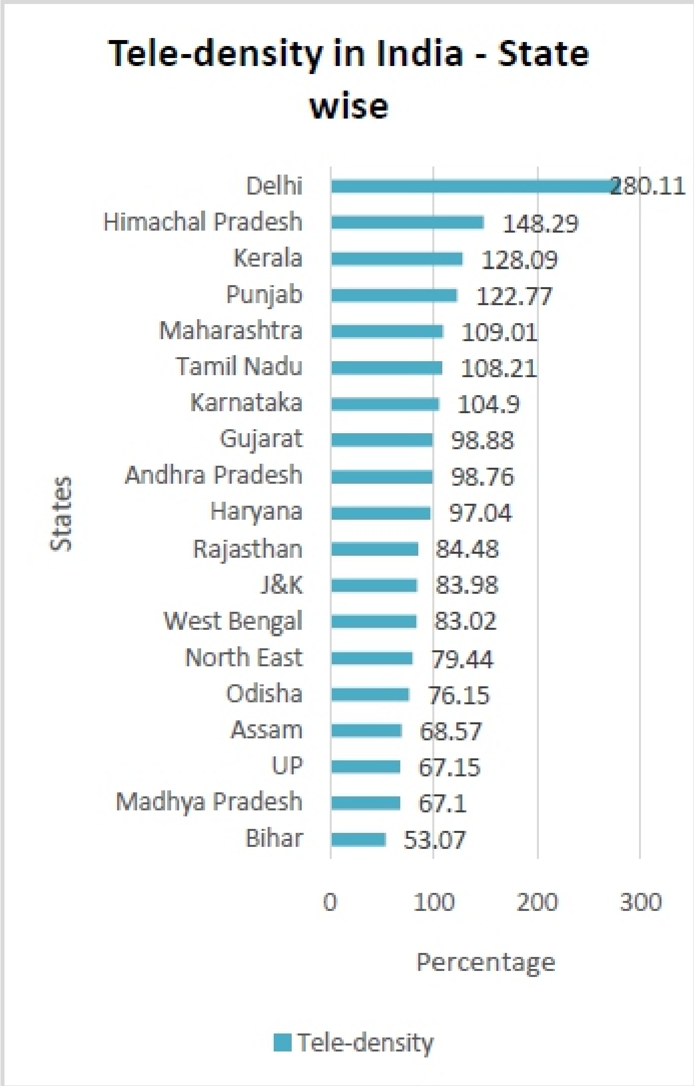


**Figure-V: State-wise Tele-density in India (TRAI report 2020)**

The above data proves the availability of mobile devices that are compatible with learning. However, the fact that connectivity is an issue is certain remote areas cannot be ignored totally, but learning English language using mobile devices could be enabled using strategies such as asynchronous learning where learner need not be online throughout during the learning process. The focus from Computer Assisted Language Learning (CALL) is taking a positive shift towards MALL. Tai and Ting (2011) have examined the fundamental issues in deploying mobile technology-mediated language learning, including teacher attitudes and challenges faced, for a feasible adoption approach. During the study, six pre-service teachers were introduced to a mobile device and asked to collaboratively design and implement MALLprogramme. Perceived usefulness, ease of use of the device, and their predisposition to innovate the device were surveyed. The findings proposed that organizational effort should focus on providing knowledge and experience of mobile technology to teachers, or arranging a special design task for teacher participation. Meurant, R. C. (2006) reviewed the implications of incorporating mobile phones in second language acquisition (SLA). In this review, he considers the intentional use of mobile phones in a class by the teachers and learners to provide ubiquitous computer-mediated SLA. The reviewed literature presents a general orientation and conceptual framework and identifies their relevance to task-based learning, the potential for distributed practice, and suitability for encouraging classroom interactivity. Both these studies provide adequate information on the incorporation of mobile devices in SLA. Khazaie, S &Ketabi, S (2011), in their study, have employed multimedia platform to develop three types of vocabulary learning materials. During the study, careful consideration was given to the different visual and verbalshort-term memories of L2 learners. 158 L2 learners aged 18-23 participated in the major phases of vocabulary learning experiment through mobile. Based on their scores on the English Vocabulary and Recall tests and statistical analysis of the results it was revealed that L2 learners with high-visual and high-verbal abilities find it easier to learn the content presented with both pictorial and written annotations. On the other hand, L2 learners with low-visual and low-verbalabilities benefit from learning materials presented without annotations. Also, delivery of learning materials with pictorial annotation to learners with high-visual ability and the delivery of learning materials with written annotation to learners with high-verbal ability resulted in better vocabulary learning.

## IV. LIMITATIONS IN INCORPORATING MALL

Currently, technology is considered to be a powerful supplementation and mode for teaching-learning processes, and has an important role in the world and affects almost every aspect of teaching and learning. Mobile learning puts forward a widerange of challenges and pitfalls for both teachers and students regarding all the mobile devices (Mohammadi, E., &Shirkamar, Z. S. 2018). Incorporation of MALL in the L2 classroom, based on the literature review, proved to be effective. On the other hand, there are certain limitations in using mobile devices in the teaching and learning process. The limitations are classified as (i) Psychological (ii) Pedagogical and (iii) Technical.

### A. Psychological limitations

Learners prefer M-learning when they are away from their classrooms. Any learning activity needs effort and brainwork. After class hours, learners prefer to relax and how many of them want to study or learn rather than relax on the bus or in the car on the way home after a long day of study? When they get home, if they want to learn, mobile devices are not likely to be their main choice. The more likely choices would be computers installed with learning software or computers with high-speed Internet access for e-learning. Mobile phones will mainly be used for communications with other people and not for learning purposes. The fundamentals of learning still do not change with mobile learning (Razak, 2004). M-learning does not replace traditional learning but is just another way of learning using new technology. A study carried out by Psychological Society in the year 2017 has identified that the fear of losing a smartphone is compared to that of the fear of a terrorist attack. The dependence on mobile application and other functions has led to a level of dependence and personal intimacy new in the human-machine relationship (Moreno & Traxler, 2016). It has been shown that mobile phone radiation does cause increases in blood pressure (Braune et al., 1998).

The learners have a fear of using mobile devices for long hours since there is information that using mobile devices for long hours would bring bad effect on the brain functions such as brain tumours and other brain or oral diseases.

### B. Pedagogical Limitations

In the context of mobile learning, learners take full responsibility for their learning activities. This disrupts teacher interventions in the process of learning. Learners lack support and guidance in the process of learning. Most organizations like to keep track of who is doing what to whom and when using some form of learning management system (LMS). Another major pedagogic limitation in M-learning courses is whether based on mobile phones or other mobile devices, it is hard to administer a test. Without on-site supervision, course organizers have no reason to trust that the answers sent from a mobile phone are being sent personally by the actual registered mobile phone holder and m-learner (Shudong & Higgins, 2006). In an M-learningenvironment, the lack of a clear pedagogical framework might lead to lack of interest and reluctance in the learners. Also, in M-learning,a learning atmosphere is absent. According to Rovai (2002), 20%-30% of the learners who enrol courses through distance learning mode such as M-learning do not finish them. Matin(2017) throws light on the explosion of mobile apps in a pedagogical concept. There are various apps available, in which the teacher and the learner should scrutinize the suitable one for their use. It consumes much time. Another major challenge is the deviation while using the apps. Even in this technologically advanced world, everyone can't have a mobile device for them. The teachers have to design the course so that no one should feel left out inside and outside the classroom.

**C. Technical Limitations**

Internet data plays a crucial role in deciding the quality of learning using mobile devices. For example, 30GB on an average seems to be huge, but it may not be enough to accommodate high definition (HD) audio and video files. HD audio and video files can be stored in mobile phone memory, but it affects the system functionality and occupies more space. Moreover, users might face slow processing speed and sometime the data might be corrupted. India is a developing country and it has to go a long way in terms of growth in the field of communication technology. Matin (2017) states that the problems associated with Wi-Fi or mobile data connection and the speed of the mobile network depend upon the speed of the internet. The speed of the mobile network depends upon the data provider and the area where the people reside .However, developed countries are accelerating in the field of technology-enabled learning with the advent of new technologies and advancement from 4G to 5G network connection. Further, everyone can't hold particular software to run the files needed for learning purposes. In the context of learning using mobile devices, studies suggest that learners, under novelty effect, shift their interest from learning to the new technology and the gadgets used for learning (Ushioda, 2013; Botero, Quester and Zhu, 2018). They further point out that the number of balanced users is very low compared to students who shift their interest and motivation.

**D. Screen Size**

As smartphones are the commonly used devices in the process of MALL, screen size comparatively is identified as a major issue that hinders easy-learning. Table 1 shows the screen size of the mobile devices commonly used by the learner (Maniar et al, 2008; Raptisa D et al, 2013).

**Table-I: Screen Size of the commonly used Mobile Devices**

| S.No | Device | Screen size |
|---|---|---|
| 1 | Mobile phone | 1.65 to 2.75 inches |
| 2 | Smartphone | 5.5 to 6.2 inches |
| 3 | Laptop | 17 inches |
| 4 | Tablets | 7 to 10.1 inches |

In any interactive communication device, the screen size plays an important role in terms of modality. Watching a short video or a movie on the smartphone screen may not cause any disturbance that might hamper the effectiveness of the process as the purpose is entertainment. However, this may not be the case when the usability is focused on learning or knowledge acquisition. Raptis, D et al (2013) have conducted a study on the effectiveness of using mobile phone or smartphone concerning the screen size for learning purposes. They have identified a significant effect of the screen size on the users. According to their study, users who interact withlarger than 4.3in screens are more efficient during information-seeking tasks. In a similar study, Jones et al (2003) have reported that screen size impacts the speed of internet searching tasks. Honarzad (2019) states that the rapid evolution of technology makes the existing devices outdated very soon and the learners and teachers go for new devices to access the latest content. Size of the screen and resolution of the screen of the mobile devices are some of the major technical limitations (Salameh, O. 2011). It is a fact that producers have improved the quality of the mobile devices in terms of screen size and resolution to a large extent, but the improved size may not be comfortable for learning purposes. It may be adequate for viewing messages and video files, but serious learning may not be possible. According to Bryan (2004), the existing screen size of the mobile devices might be all right for viewing text for a short time, but usually not for longer than two to three minutes. If learners exceed this time limit, their eyes will become tired. Another major limitation of using a mobile phone in the learning process is its data storage space. Moreover, apart from availability, affordability becomes a problem. In developing countries, to afford a mobile device with uninterrupted connectivity may not be available to every learner who understands the modality, and, despite the cost, the new communication and connectivity facilities offered by smartphones have made them a „must-have" products. (Godwin-Jones, 2017).

## V. ADVANTAGES OF IMPLEMENTING MALL

Tayebh states as a contradictory approach to classroom learning atmosphere, Mobile Assisted Language Learning (MALL) assists students to learn irrespective of barriers associated with time, place and situation.

Advantages of MALL are mainly marked for its synchronous and asynchronous mode of learning. Despite the above-discussed limitations in MALL, Thornton and Houser (2005) show that mobile devices can indeed be effective tools for delivering language learning materials to the students. As mobile technologies provide many advantages: flexibility, low cost, small size and user-friendliness, researchers are exploring how to use mobile technology to support language teaching-learning (Huang et al., 2012). Until 2019 or before the pandemic COVID 19 attack, the use of mobile devices for learning was very limited. Dushtestani, (2016) and Nino (2015) have identified that, based on the literature, the usage of MALL outside the classroom for learning was very minimum. This scenario has completely changed during the pandemic as the schools and colleges have sifted to a mobile learning platform for the teaching, learning and assessment procedures.

### A. Self-Directed Learning (SDL)

SDL is one of the basic human tendencies and competencies where a person participates in activities generated by himself/herself, through which he/she learns (Hiemstra, 1994). Teachers and students may use SDL in the process of organizing the teaching-learning process (Fisher et al., 2001). It has a positive impact on the process as it motivates both teachers and students; also, enables cognitive learning experience (Garrison, 1997).Figure 6 shows the different dimensions of SDL – self-management, self-monitoring and motivation.

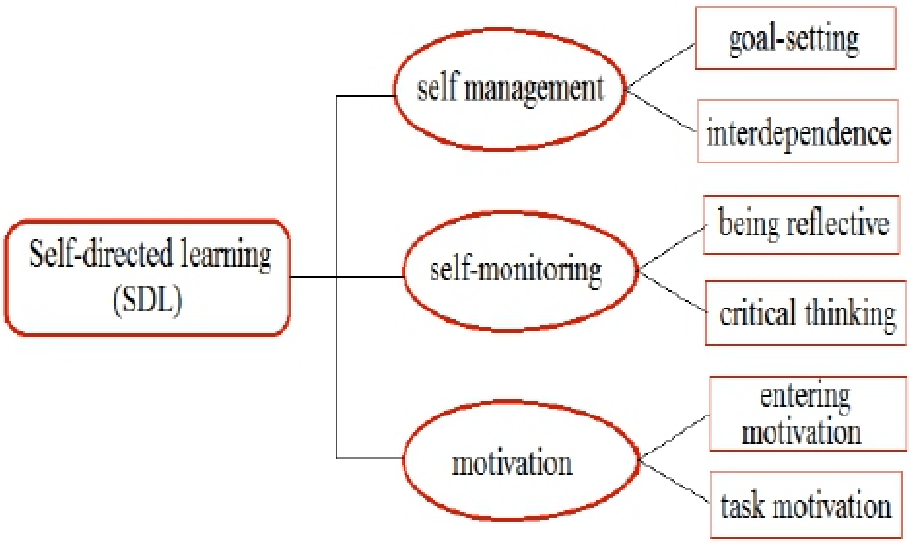


**Figure-VI: Dimensions of Self-directed learning (SDL)**

According to Garrison (1997), to be reflective and to be able to think critically form the metacognitive aspects of self-monitoring dimension of SDL, MALL is an effective platform. Moreover, these two aspects are considered important variables in MALL. Another aspect that plays an undeniable role in MALL is motivation. Studies have proved that motivation, as a learner variable, could be quantified (Patrick, Skinner, and Connell, 1993). They have found that perceived control strongly predicted students" persistence, attention, effort, and participation. Recent studies on SDL integrates it as a specific characteristic and a learning process where several psychological, educational and environmental factors should be considered (Stockwell, 2008). According to Lai (2013), factors related to the attitude of the learners such as the beliefs about the value of and personal consideration toward technology use for performance also play an important part in determining technology use in the process of learning.

## VI. CONCLUSION

Thus, this paper deals with the various limitations associated with the implementation of Mobile Assisted Language Learning from the psychological, pedagogical and technical perspective. In short, Indians still believe in the traditional teaching method which resists them from engaging in technology-enabled learning. We are lacking behind in most of the technological advancement as that of the foreign countries. Technological limitations as that of small screen size, small memory and the lack of common standards resist people in using mobile phones for language learning purpose. The phone makers and telecommunication companies should take an effective step to overcome such technological and psychological limitations. Otherwise, mobile learning will not be possible in practical life. These limitations should be seriously considered by the educationists and they should find an alternate resource for overcoming the difficulties. Teachers have to design different learning materials specifically for mobile platforms.

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# Hybridization of Machine Learning Techniques to Optimize Portfolio of Stock Market: Review of Literature from the Period 2005 to 2018

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## A B S T R A C T

*In finance there has always been the problem of how to combine investments to form a portfolio. Progress on this problem we focus on some of the important applications such as Forecasting, Trading, Portfolio Selection and Management of Stock Market is considered as one of the fundamental building block of developed country. If number of investor's increases then the economy of the country also increases and every investor invests to get good returns. But as stock market is uncertain and complicated the selection of good scripts are considered as one of the challenge in stock market field. So much work has been donein this field, The purpose of the present study is to review research articles from the period 2005 to 2018 and to find research gap for future work.*

***KEYWORDS: Stock Market, Machine Learning Techniques, Fuzzy, Neural Network, Portfolio, BSE Stock Exchange, NSE Stock Exchange.***

## I. INTRODUCTION:

Optimization is a process by which the most constructive transaction between competing interests is determined subject to the constraints faced in any decision making process. Within the context of portfolio management, the competing interests are risk reduction and return enhancement among the other interests. Stock Market Portfolio Optimization is the main foundation for the investment in capital market with huge uncertainty and confusion. So much work has been done related to portfolio selection, prediction and management called as Portfolio Optimization, which helps in decision making for investors to get better return against their investments and to improve efficiency of portfolio. Towards this study the first research is been conducted by Markowitz in 1952 introduced about the diversification of total amount of the investor using Mean-Variance Model. This work has created new horizons, assumptions and more scope for further research and the Linear programming model has been introduced by Konno-Yamazaki and then Werner has combined both the ideas and developed Fuzzy Linear Programming Model. Fuzzy set theory is used in this model which was first introduced by Zadeh is able to handle uncertainty which is more in the behaviour of stock market and to handle inadequate information about returns on investment. Stock market is considered as one of the most important economic pillar of each country where public companies raise funds by issuing shares to public and Institutions.

Furthermore, a future trading is not only popular in developed markets of the world, but is equally popular in emerging markets like India. More than 8000 public companies are listed in Indian stock market which is evident from the fact that Indian equity future is ranked in top 5 in the list of world stock market from last two decades. Indian Stock Market (both BSE and NSE) offers an average of more than

25,00,00, 000 stocks, This makes an approximate business of more than 2000 cr. By purchasing these scripts, an investor becomes partial owner of the traded company which creates a portfolio of individual investors. Stocks are exchanged among buyer and sellers which generate a huge transaction data and prices keeps on changing as perdem and and supply of stocks. All trading data is captured by stock exchange where stock companies are listed. Stock trading data is non-linear, fluctuating and uncertain hence highly time variant. Huge information is hiding therefore extracting and analysing such huge market data will be beneficial to individual investors to make their portfolio strong. When we speak about portfolio then the investor thinks about strong, correct and high return scripts against investment. Accordingly each investors has to be practical rather than emotional or sentimental hence study of many parameters and historical data using some powerful tool is vital to design strong portfolio, Considering above points, rotation of money is also vital in portfolio and to achieve this buying and selling both are important. As per the current scenario, the process of buying and selling of equity is called portfolio development and management which helps to minimize risk, to earn profit and also helps to book profit and loss. Hence to select , predict and to optimize the patterns generated in this Stock Trade over the period of time from Indian Stock market is essential, Also rotation of money in the portfolio is a key requirement. An application based on Machine Learning Techniques is the right choice in the current scenario. The research work intends to construct and design correct investors portfolio by developing hybrid model using machine learning techniques such as Data Mining, Statistical computations and soft computing techniques.

**A. Machine Learning Techniques (ML):**

Technological and computational advances and up gradation of hardware and software ultimately leads to generate floods of data which has led to use machine learning techniques for optimization problem in the field of financial stock market.

ML is the whole lot on the list.

It is well thought-out a subfield of Artificial Intelligence (AI) and consists of learning models. ML allows the program to make predictions on data. It is more than just a list of instructions which clearly define what the algorithm should do. Moreover, it is linked to Computational Statistics which uses learning models. A learning models allows algorithm to learn the input and output combinations and then make its own decision on new data. This allows machines to perform tasks which are not possible to perform. Such tasks can be as simple as recognizing human handwriting or as difficult as self driving cars.

There are many key industries where ML is making a huge impact, these industries are Stock market ,other Financial Industries, Health Care, Education System, Marketing and Sales etc. Recently after reviewing many research papers authors learned that traders in stock market started using Machine Learning techniques because, to make use and advantages of different ML techniques, such as Supervised and Unsupervised, Reinforcement and Deep learning is efficient to generate rules for programs and has more heuristic approach, which has many techniques such as Natural Language Processing, Robotics, SVM, Genetic algorithm, ANN, Baysian learning, Rule induction, Decision tree, Clustering etc used for prediction ,classification, categorizing, planning, selection, analysis and optimization.

## II. PRIOR WORK

Researcher has thrown some light on the literature review related to the studies of Capital Market, Stock Market and Stock Exchange. In this section previous work done in the field of stock market, portfolio selection, prediction and optimization using machine learning techniques such Data Mining algorithms, soft computing approach and statistical methods using different tools suitable such as R, Python ,and Mat Lab to the problem defined, are reviewed from the period 2005 to 2018 in a few words.

**Ralph E. Steueret al(September 2005)** they compared standard investors with one objective and a non standard investors with multiple objectives such as short selling, dividends, social liability, liquidity etc. these multi objectives are considered using Stochastic programming and deterministic formulations to select and optimize portfolio. Authors' suggests that there is a huge scope to explore algorithms to compute well organized and non-dominated sets of EDP with more linear objectives.

**Nirbhey Singh Pahwa, Neeha Khalfay et al. (2017)** conducted a survey to predict stock market with reference to BSE Stock Exchange using machine learning techniques. Based on the prior work, authors proposed a system to extract knowledge from the collected information and recommended to use supervised learning method of ML which has many different methods, among them they have suggested to use linear regression and logistic regression for prediction and analyses of the data collected from BSE SENSEX of Indian Stock Market. And they have also recommended Support Vector Machine Algorithm to optimize accurate results. Towards this study the first research is been conducted by Markowitz (1952) introduced about the diversification of total amount of the investor using Mean-Variance Model. This work has created new horizons, assumptions and more scope for further research and the Linear programming model has been introduced by Konno-Yamazaki and then Werner has combined both the ideas and developed Fuzzy Linear Programming Model.

**The author Fatih Konak et al. (2016)** has used the same base of Fuzzy Linear Programming to develop model for decision making using investors experience and knowledge and past performance of stocks in different sectors which are selected from FTSE 100 stocks listed in the Turkey Index. In this model the Linear Programming is divided into three main parts such as purpose functions, fuzzy restricts and decision variables. In the proposed model purpose functions and purpose function coefficient together is taken as fuzzy target and both fuzzy target and fuzzy restricts are used to make fuzzy decisions. Authors suggested this model when the problem have fuzzy parameters and can be modelled by using linear function which allows investors to create portfolio according to their behaviours from FTSE-100 shares. Initially authors made decision about fuzzy parameters and techniques and then membership functions are created to describe the structure of the purpose function. After this a linear function is applied to develop a model. This method helps to analyse portfolio using financial indicators such as Price/ Earning per ratio and collection distribution index by adding constraints. Authors concluded that the British American Tobacco and Hikma Pharmaceuticals stocks should be included in the portfolio with 0.7% return and 9.6% risk.

**Mehdi Alinezhad Sarokolaei et al. (2013)** has conducted research on Fuzzy Optimization on listed stocks of Tehran Stock Market Portfolio based on portfolio value at risk using mean absolute deviation method. They have developed hybrid intelligent algorithms such as genetic with fuzzy logic to optimize portfolio at the confidence levels of 95% and 99% with the use of parametric method. They used genetic single-stage Roulette Wheel technique and generated 2000 generations with 20 populations each using MATLAB tool. In their research 15 stocks with 7 years of time period has been considered to calculate value at risk by taking 6 criteria's such as Asymmetric and Symmetric Value at Risk, Interval Value at risk with (5% to 95%) and (10% to 90%) interval, Normal Value at Risk and Value at Risk based on the Mean Absolute Deviation [1] are considered as fuzzy variables [4]. They concluded in their research is that the calculated probability ratio using Kupiec statistic method based on six criteria's for fuzzy optimization model is more larger than critical value obtained from chi-square distribution at the confidence level of 95% and it also indicate that the model at risk based on mean absolute deviation function gives more accurate result. Therefore according to the authors fuzzy variables are more suitable to handle asymmetric uncertainties in financial domains [4].

**P. Divya and P. Ramesh Kumar (2012)** states that the traditional method and new method of asset selection and optimization of investor's portfolio.

To select a profitable asset which makes a better portfolio and to optimize this portfolio, they have considered fuzzy – genetic algorithm. To optimize non linear data and to handle uncertainty present in the stock market they had considered four financial indicators of some listed companies such as price/earnings ratio (P/E ratio), return on capital employed (ROCE), Earning per share (EPS) and Liquidity ratio are taken as input variables to find the quality of each listed companies for investment according to the score given to rate these companies. And the output variable is investment ranking as per the annual price return (APR). The researchers have concluded that with the use of Fuzzy logic and Genetic Algorithm optimization, the section of scripts for investments are ranked as per the fundamental financial information and price return on investment. This model helps investors to select the top investments to construct efficient portfolio which is able to manage uncertainty and risk.

**Masafumi Nakano et al. (2017)** has developed a new Knowledge based system called as Expert System using Fuzzy logic with particle filtering and anomalies detection to select different scripts with fine risk-return profiles from the number of listed scripts by combining multilateral performance measures. They have developed ES considering three criteria's such as Estimation, Portfolio construction and selection with a Fuzzy logic system [6]. They have considered Exponential moving average (EMA) model for different smoothing factors to prevent anomalies such as expected return and volatility which is estimated using many time series models such as by particle filtering with anomaly detectors, and then calculates Mean-Variance optimal portfolio weights.

Finally taking historical data of each script based on Fuzzy logic system by integrating different investment criteria's such as compound return (CR), standard deviation (SD), downside deviation (DD), maximum drawdown (MDD), Sharpe ratio (ShR), Sortino ratio (SoR) and Stering ratio (StR), which enable multilat- eral assessment to select best portfolio. This numerical experiment has confirmed that the Expert system generates reasonable investment record helps to construct efficient portfolio.

**Oguzhan Ece et al.(2017)** in their research paper titled " Applicability of Fuzzy TOPSIS Method in Optimal Portfolio Selection and an Application in BIST" discussed about to find out the availability of alternative method to determine the best script with the combination of managing risk and return perspective of investors who would like to evaluate their investments in capital market. And to achieve these, authors has used FUZZY TOPSIS method mainly used for multi-criteria decision making to get optimal portfolio. Researchers has considered a list of stocks suggested by different trade houses for investors of Johnson and Sharp Indexes, and then common stocks among them are selected and sorted using Fuzzy TOPSIS method, then the ranking is applied according to the performance of individual scripts, they compared with the performance of the portfolio constructed using Markowitz traditional portfolio theory. They found that fuzzy TOPSIS method works better based on risk return, performance and other results. Researchers suggests that the Fuzzy TOPSIS method uses linguistic evaluation of the experts called as decision makers, there is more possibilities to improve efficiency of the portfolio according to the knowledge of the experts.

**Novriana Sumarti,Patricia Nadya (2016),** In the research paper titled "A Dynamic Portfolio of American Option Using Fuzzy Binomial Method" has discussed about the new fuzzy model using Binomial CRR for computing the optimal stock price of American Option prices. They considered three types of price movements of stocks such as bearish, bullish and sideways. According to the researchers fuzzy binomial CRR model helps investors to adjust their portfolio according to the price movement. They considered simplified trading market to get return of 8.998% for 5 trading days. This model helps to take decision about to buy or sell the stocks based on membership degree of fuzzy. Researchers suggest that other variables in binomial option pricing model can be used to fuzzify to get better results.

**bolfazl Kazemi et al. (2017)** discussed about Goal Programming using fuzzy logic with probabilistic constraints to get efficient portfolio. In their research they believed that return of risky stocks were random variables and objectives such as risk, return taken from Markowitz (Markowitz 1952) and dividend yields attainability had fuzziness. They found that two main objectives such as risk and return had normal distributions therefore added divided yield as third objective which have discrete distribution to maximize return, divided and minimize risk. In Markowitz's model risk is based on mean-variance of return whereas using goal programming risk is calculated considering two patterns of sharp coefficient and variance of return using the result of the model. They concluded that divided yield in the fuzzy goal programming model is better than Markowitz's constraint model. Researchers recommend stochastic programming with fuzzy concept. And to consider more objectives and develop a decision support system for selecting portfolio, to recognize indices that have more impact on the risk and return of portfolio.

**EddieChi Man Hui et al. (2009)** had focused on fuzzy concept with linear programming to get best portfolio of real estate investment. He has considered Hong Kong portfolio for local people, they had taken data from Hang Seng Composite Industry Index(HSCII) , Hong Kong Dollar Bond Index and Private Domestic Price Index with the historical data and collected experts judgement. An author suggests that real estate helps to hedge uncertainties such inflation and interest rate volatilities which helps to change the investment behaviour. To achieve this researcher applied fuzzy tactical asset allocation flexible programming model helps to construct portfolio more efficiently than traditional method. Authors said that this model fails to minimize risk and to select high risk scripts into the portfolio. They suggest that investors should study carefully and look into its disadvantages of each script before investment. They also suggest focusing on the development of membership functions for determination approach. This model is not suitable for optimization if there are too many constrains are present. This model is not suitable for optimization and this model is difficult for laymen to implement.

**Mualla Gonca et al.(2012)** has discussed in their thesis about the Fuzzy Rule based Expert System to support portfolio managers to make decisions about middle term evaluation of stocks and construction of portfolio and also the system handles uncertainty exists in the relationship between fundamental and technical criterion. In this study, for portfolio construction they have used mixed integer linear programming model which helps to select high rated scripts in the portfolio. In the theses the expert system is validated from 2002 to 2010, they have considered 61 equity scripts which are listed in Istanbul Stock Exchange (ISE) i. e National-100 Index (XU100). The performance of expert system is evaluated by comparing with benchmark index (XU030), and proved the performance of ES is better than the benchmark index. Also the ES is better in case of risk averse investor profile and middle term investment period.

In their study the author comprised macroeconomic factors such as GDP, inflation rate etc which highly affects stock market of any country. Author suggested that by considering these macroeconomic parameters, the proposed ES can be used in international investment case and helps to reduce risk level of the portfolio. It is further suggested that while gaining knowledge, we can apply group decision making approach. They have also mentioned some more approaches to handle uncertainty other than Fuzzy model, such as Bayesian algorithm, Demster and Shafer's belief functions.

To use stock market, data base for better perceptive, there is a requirement to discover unsupervised learning and deep learning which include both data mining and soft computing techniques along with some statistical techniques that amalgamates the data with theoretical developments to benefit the users. M Gunasekaran et al. (2012) proposed Neuro-Fuzzy model to optimize portfolio considering Indian Stock Market. They had taken BSE INDEX considered both price and volume data to forecast stock market by applying hybridization of Neuro–Fuzzy model based on Fuzzy logic theory and fuzzy set and integrated with Fuzzy Inference System (FIS) and adaptive neural network system. Using this hybrid model neural network learning algorithm is implemented and proved that this model gives higher returns than other model.

**Kranthi Sai Reddy (2018)** explained about the prediction of a stock market using machine learning techniques such as Support Vector Machine by Radial Basis Function Kernel to predict price movement of stocks for large and small caps from global financial market, and considered daily and up-to-the minute frequencies. In this study researchers proposed python programming tool to implement machine learning approach that will be trained from collected daily stock prices and extract intelligence to predict the market. This study has concluded with high returns as compare to other model.

**Ronald Baganzi et al. (2017)** states that R tool is more suitable for statistical computing to analyse portfolio optimization models including Markowitz's Mean-Varience model, the VaR model, Konno and Yamazaki's Mean-Absolute Deviation model. They have analysed multi asset's historical data collected from the top most indexes in the world of 16 constituent scripts listed in USE i.e Uganda Securities Exchange for the time period of 6 years. They found results of the model and discussed about most dominating bond was GREXP on world market, because analysis result has shown 60% of the Maximum Diversified Portfolio. They have used different risk measures such as Sharpe Ratio, Expected Shortfalls, Volatility, Risk Parity to evaluate stock performance for Uganda Stock Exchange to identify more dominating scripts. Finally it is concluded that UMEME, EBL, KCB, CENT etc were the more dominating and better performing scripts by using R tool, and this model helped Uganda investors to make decisions about which stocks to be included in their portfolio.[2]

**Osman Hegazy et al.( 2013)** discussed about machine learning model with the integration of supervised learning algorithms such as Particle Swarm Optimization and LS-SVM to forecast stock price using technical indicators such as moving average, convergence and divergence, stochastic oscillator, money flow index, relative strength index etc. They have explored that Particle Swarm Optimization (PSO) is implemented iteratively as global optimization algorithm to optimize LS_SVM for price prediction, and is used in the selection of LS-SVM parameters such as kernel, cost penalty and other parameters. And this model is called as LS-SVM-PSO model which is capable to overcome the over-fitting problem found in ANN. Also PSO-LS-SVM algorithm parameters can be tuned easily. The above model was tested for all sectors of S&P 500 stock market. These sectors are Information Technology (Adobe, Hp, and Oracle), Financials (American Express and Bank of New York), Health Care (Life Technologies, and Hospera), Energy (Exxon-Mobile and Duck energy), Communications (AT&T), Materials (FMC Corporation); Industrials (Honey Well). It is proved that this model performs and gives better results than ANN using back propagation model.

**Jigar Patel et al.(2015)** had developed two stage fusion approach using Support Vector Regression (SVR) at first stage and ANN, Random Forest (RF) at second stage. By combining both by using hybridization technique SVR-ANN and SVR-RF and SVR-SVR models were developed. This model is implemented on two indices namely CNX Nifty and S&P Bombay Stock Exchange of Indian Stock Market for experimental evaluation. They had considered 10 years of historical data of both indices and technical indicators are used as input to each of the model. The predictions are made for 1–10, 15 and 30 days in advance. The result of prediction using these hybrid models were compared with single stage scenarios such as ANN, SVR and RF and concluded that hybrid models perform better than single handed models.

**Samer Obeidat et al.(2018)** in their research paper authors has proposed a very recent machine learning technique such as Deep learning used to automate portfolio management and to improve risk adjusted returns. Authors have considered Long Short –Term Memory (LSTM) approach to adaptive asset allocation to recommend personalized portfolio. In this study historical price data is collected and calculated based on macroeconomic data and used other market indicators using principal component analysis to develop Neural Network using Deep Learning method.

This model is implemented to estimate the expected return, volatility level and to find correlation between selected scripts in the portfolio. Then the output of this action is optimized using Mean-Variance statistical technique and further improved to use forward looking rolling window technique. This was implemented and tested on collected data explored that a long short term memory model can generate better risk adjusted returns compared to strategic passive portfolio management.

**S.R. Nanda et al. (2010)** in their research paper titled Clustering Indian Stock Market Data for Portfolio Management. In this study researcher has presented integration of Data Mining clustering techniques such as K-means, SOM and Fuzzy C-Means to classify huge number of stocks into clusters for portfolio management. This hybrid model of clustering techniques is build to get efficient portfolios. Authors have collected data of stock returns at various times with their valuation ratios from the stocks of BSE sensex of the year 2007-2008. Hybrid model of clustering is tested on this data and analyzed. After analysis, it is concluded that K-Means cluster technique is more efficient than compared to SOM and Fuzzy C Means clustering algorithms.

**According to the authors MelekAcar Boyacioglu et al.(2010)** focused on to predict stock market price movement and stock market return. They used monthly six macroeconomic variables and three Indices such as DAX, BOVESPA, DJI and ISE National 100 return. Researchers have collected data from Central Bank of the Republic of Turkey electronic data delivery system and Metrics Information

Delivery System Inc. Researchers have collected 228 observations and divided into training and testing data. The experimental results that the model effectively predicts monthly return of ISE National 100 Index with an accuracy of 98.3%.

**Kuang YuHuang et al. (2009)** as per the researchers a Moving average autoregressive exogenous (ARX) model is more suitable for prediction which is combined with grey system theory and rough set(RS) theory and applied to Taiwan Market to generate automatic selection and prediction mechanism. In this approach, data is collected automatically every quarter and are used to input to an ARX prediction model which predicts future trends for next quarter. This predicted data size is reduced using GM (1, N) model, and clustered using K-Means algorithm. These clusters are applied to Rough Set classification model to select correct stock by applying set of rules. Then using grey relational analysis technique each selected stock is weighted which helps to maximize rate of return of each portfolio. They had validated the proposed work using E Stock data maintained by Taiwan Economic Journal. And this model is compared with GM (1, 1) prediction method. And proved that hybrid model has greater forecasting accuracy than GM (1, 1) model.

**Pankaj Gupta et al (2012)** have proposed an integrated approach to develop model to select portfolio for multi criterion decision making. In this paper they have used Support Vector Machines which is a machine learning technique which uses statistical learning methods for asset classification purpose and then it was blended with Real Coded Genetic Algorithm to each class found by SVM algorithm to build optimal portfolio which are based on short term return, long term return and liquidity.

**Ms. Anju bala(2013)** reviewed about Indian Stock Market written about different authors and concluded that the overall Stock Market is the alleviation of risk by investing in multiple scripts. Author has discussed about the history of different stock exchanges present in India such as Bombay Stock Exchange, National Stock Exchange and Calcutta Stock Exchange. She found that these Indices did not follow random walk and its movements are largely based on GDP, Inflation, FII, Macro economical factors and political stability etc.

**Ms. Keerti Mahajan et al (2015)** authors has well thought-out the financial indicators of Indian Stock Market (Nifty-50) as a input to the fusion of Neuro-Fuzzy system and collected data of historical quarter results to train and predict to select scripts.This ANFIS model helps to make decisions about whether to Buy, Hold or Sell scripts.Authors suggested that considering more number of Financial Indicators and Technical Indicators more accurate prediction can be done and also they suggest to use Machine Learning techniques to predict Stock Market.

**Hossein Dastkhan et al(2011)** worked on Fuzzy Weighted Min-Max model using Konno's(2003) Mean –Absolute deviation for Portfolio Selection problem with multi objective and real features. The real features considered are transaction lots, variable transaction costs and cardinality and bounds on holding constrains. And for the resulted model researchers applied a Hybrid Genetic Algorithm. The model was based on empirical study and considered 75 assets of New York stock exchange as sample. The fuzzy portfolios model was compared with the performance of crisp portfolios and S&P 500 index and found that proposed model perform more efficiently. To achieve objective two non-linear logistic membership functions are used such as fuzzy weighted additive model and logistic membership functions.

The Table 1 shows efforts made for the successful implementation of Machine Learning Techniques, Data Mining, Soft Computing and Statistics to Stock Market different countries from the period 2005-2018

**Table 1: Summary of Stock Market Research in different Countries**

| Author | Title | Technology | Index |
|---|---|---|---|
| Ralph E. Steuer ,et al(September 2005) | Multiple Objectives in Portfolio Selection" | Stochastic Programming and deterministic formulation | Germany |
| Eddie Chi Man Hui , Otto Muk Fai Lau & Kak Keung Lo,(2009) | A fuzzy decision-making approach for portfolio management with direct real estate investment | fuzzy concept with linear programming to get best portfolio of real estate investment. | Hang Seng Composite Industry Index(HSCII) |
| Kuang YuHuang,Chuen-JiuanJane Apr-09 | A hybrid model for stock market forecasting and portfolio selection based on ARX, grey system and RS theories | Moving average autoregressive exogenous(ARX) model with grey system and RS theories | Taiwan Stock Market |
| S.R. Nanda, B. Mahanty, M.K. Tiwari(2010) | Clustering Indian stock market data for portfolio management", | Data Mining techniques such as K-means, SOM and Fuzzy C-Means | BSE sensex |
| Melek Acar Boyacioglu et al.(2010) | An Adaptive Network-Based Fuzzy Inference System (ANFIS) for the prediction of stock market return: The case of the Istanbul Stock Exchange", | Adaptive Neuro –Fuzzy iInference System | Applied to three Indices such as DAX, BOVESPA, DJI and ISE National 100 return (Istanbul Stock Market) |
| Hossein Dastkhan, Naser Shams Gharneh, HamidReza Golmakani(2011) | A linguistic-based portfolio selection model using weighted max–min operator and hybrid genetic algorithm", Expert Systems with Applications | Fuzzy weighted max–min operator and hybrid genetic algorithm | NYSE ,S&P 500 |
| P.Divya, P. Ramesh Kumar(2012) | The Investment Portfolio Selection Using Fuzzy Logic And Genetic Algorithm | Soft computing techniques such as Fuzzy Logic and Genetic Algorithm | Indian Stock Market |

| | | | |
|---|---|---|---|
| Mualla Gonca YUNUSOĞLU,(2012) | A Fuzzy Rule Based Expert System For Stock Evaluation And Portfolio Construction: An Application To Istanbul Stock Exchange", | Fuzzy Rule Based Expert System | Istanbul Stock Exchange |
| M. Gunasekaran, K.S. Ramaswami(2012) | Portfolio Optimization Using Neuro Fuzzy System In Indian Stock Market", | Hybridization of Neuro–Fuzzy model based on Fuzzy logic theory and fuzzy set and integrated with Fuzzy Inference System (FIS) and adaptive neural network system | BSE Index(Indian Stock Market) |
| Pankaj Gupta et al (2012) | Asset portfolio optimization using support vector machines and real-coded genetic algorithm", | Support Vector Machines blended with real coded Genetic algorithm | Indian Stock Market |
| Ms. Anju bala(2013) | INDIAN STOCK MARKET - REVIEW OF LITERATURE" | Review | Indian Stock Markets |
| Mehdi Alinezhad Sarokolaei et al. (2013) | A Fuzzy Model for Fuzzy Portfolio Optimization with the Mean Absolute Deviation Risk function | Mean absolute deviation, hybrid intelligent algorithms such as genetic with fuzzy logic | Tehran Stock Market |
| Osman Hegazy et al. -2013 | A Machine Learning Model for Stock Market Prediction | supervised learning algorithms such as Particle Swarm Optimization and LS-SVM | S&P 500 stock market |
| Jigar Patel et al.(2015) | Predicting stock market index using fusion of machine learning techniques | Two stage fusion approach using Support Vector Regression (SVR) at first stage and ANN, Random Forest (RF) | CNX Nifty and S&P Bombay Stock Exchange |
| Keerti. S.Mahajan et al.(2015) | Portfolio Investment Model Using Neuro Fuzzy System | ANFIS | Indian Stock Market |
| Fatih Konak et al. (2016) | Fuzzy Linear Programming on Portfolio Optimization: Empirical evidence from FTSE 100 Index | Fuzzy Linear Programming | Turkey Stock Market |

| | | | |
|---|---|---|---|
| Novriana Sumarti,Patricia Nadya (2016), | A Dynamic Portfolio of American Option Using Fuzzy Binomial Method | Fuzzy Model using Binomial CRR | American Stock Market |
| Nirbhey Singh Pahwa, Neeha Khalfay et al. (2017) | Stock Prediction using Machine Learning a Review Paper | Support Vector Machine Algorithm | BSE Stock Exchange |
| Masafumi Nakano et al. (2017) | Fuzzy logic-based portfolio selection with particle filtering and anomaly detection | Fuzzy Logic | Tokyo Stock Exchange |
| Oguzhan Ece et al.(2017) | Applicability of Fuzzy TOPSIS Method in Optimal Portfolio Selection and an Application in BIST | Fuzzy TOPSIS | Johnson and Sharp Indexes |
| Ronald Baganzi et al. (2017) | Portfolio Optimization Modelling with R for Enhancing Decision Making and Prediction in Case of Uganda Securities Exchange | Mean Absolute Deviation Model | Uganda Stock Exchange |
| Abolfazl Kazemi et al. (2017) | A Fuzzy Goal Programming Model for Efficient Portfolio Selection | Goal Programming with Fuzzy Logic | Iran Stock EMarket |
| Samer Obeidat et al.(2018) | Adaptive Portfolio Asset Allocation Optimization with Deep Learning" | Deep Learning(Machine Learning) | S&P 500 US Stock Market |
| Kranthi Sai Reddy (2018) | Market Prediction Using Machine Learning | Support Vector Machine by Radial Basis Function Kernel | Indian Stock Market |

## III. FINDINGS:

From the above symposium, authors found that, the current work reviewed the Stock Market, its different parameters such as Financial Indicators, Technical Indicators, Macro economic factors etc since the year 2005 to 2018. The research work indicates that the decade from 1952 to 2018 has contributed towards the development in the performance of Stock Market using various techniques. The researchers in this decade have investigated different routes that will lead to form the Stock Market with Optimum risk and return. And later most of the papers reviewed focused mainly on Prediction, Forecasting and Optimization using Soft Computing techniques, Machine Learning techniques considering multi objectives which shown the improvised and clear results.

• Initially researcher (Markowitz 1952) involved in the mean-variance analysis for Portfolio selection (PS) which focused only on risk adjustment with little return.. And no effort been taken on other factors to select optimum portfolio. Therefore it is found that using this mean-variance technique portfolio analysis is done assuming that the investors are interested only with returns attached to specific levels of risk during selection of portfolio.

- It is also found that institutional investors typically use mean-variance optimization in portfolio selection because; it needs only the knowledge of expected returns, standard deviation and correlations of portfolio's mechanism.
- While the other type of investors prefer to use full scale optimization. This will be considered as an alternative to mean-variance optimization. Since computational advances now allow us to perform such full scale optimization under this approach
- Later according to Konno and Yamazaki shown that the use of mean-absolute deviation model can handle the analysis of portfolio problem in a more realistic approach considering multiple objective instead of one, such as transaction cost, transaction lot and minimal transaction unit in an efficient manner using branch and bound algorithm. Later many researchers applied Fuzzy Min-Max weighted algorithm with mean-absolute deviation model to get more optimized result.
- From the above review it is also found that if we consider more factors of stock market which includes liquidity, asset class,asset region, micro economics,macro economics and market dynamics, then we can get more optimized result.
- In recent papers it is found that within the context of portfolio management, the competing interests are risk reduction and return enhancement and a rise in overall personal satisfaction.

And then found that a significant advance have taken place in recent years in the field of Machine Learning. This is considered as a higher level of computerized automation of the solution and modelling process.

The use of Machine Learning for stock Market is a key activity that allows the machine to go through hundreds of Technical Indicators, more number of Financial Indicators and other Macro Economic Factors and Investors sentiments instead of a few old preferred indicators and let the machine learn and decide which indicators perform better in Prediction, Forecast and to Optimize the correct market trend.

## IV. CONCLUSION

Initially manual traders have an understanding of the markets with simple trading strategies. These strategies use a few technical indicators to predict market trend. After reviewing above research papers authors learned that traders in stock market started using Machine Learning techniques because, to make use and advantages of different ML techniques, such as Supervised and Unsupervised, Reinforcement and Deep learning is efficient to generate rules for programs and has more heuristic approach, which has many techniques such as Natural Language Processing, Robotics, SVM, Genetic algorithm, ANN, Baysian learning, Rule induction, Decision tree, Clustering etc used for prediction ,classification, categorizing, planning, selection, analysis and optimization. ML allows the machine to go through hundreds of Technical Indicators, more number of Financial Indicators and other Macro Economic Factors and Investors sentiments instead of a few old preferred indicators. According to authors an application based on Machine Learning Techniques is the right choice in the current scenario. And also found that the traders who has done quantitative research ,backtesting and optimization has higher chances of performing in live markets. Therefore the research work intends to construct strong and design correct investors portfolio by developing hybrid model using machine learning techniques.

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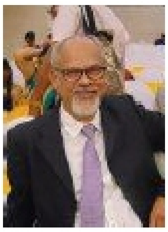

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