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Message from Chief Editor

It is my privilege to present the inaugural volume of PICT's International Journal of Engineering and Technology. As Chief Editor, I am thrilled to introduce the culmination of rigorous research and scholarly contributions in this first issue. This journal aims to serve as a beacon of knowledge, fostering innovation and advancement in engineering and technology fields.

Within these pages, readers will discover a wealth of insights and discoveries that showcase the forefront of technological evolution. Volume 1 - Issue 1 of our journal reflects the dedication and scholarly pursuit of our contributors. Their work not only expands upon the current state-of-art technologies but also provides invaluable insights into their practical applications.

PICT's IJET is committed to fostering discourse and collaboration in the global academic community. Through the dissemination of cutting-edge research, we strive to catalyze progress and drive positive change in the world. As we embark on this mission together, I invite readers to immerse themselves in the rich web of knowledge presented within these pages.

I extend my heartfelt gratitude to all the authors, reviewers, and editorial team members whose tireless efforts have made this publication possible. May Volume 1 - Issue 1 of PIJET inspire curiosity, innovation, and collaboration among scholars worldwide.

Dr. S. T. Gandhe
Chief Editor - PIJET
Principal
Pune Institute of Computer Technology
Pune, India.

Message from Journal Coordinator

I welcome authors, scholars, and readers alike to the Volume 1 - Issue 1 of PICT's International Journal of Engineering and Technology. Within these pages, you'll discover cutting-edge insights spanning various topics in domains like Electronics and Telecommunication, Computer Science, Information Technology, Embedded Systems, etc. Our goal is to equip you with the knowledge of emerging techniques and technologies to drive successful research in your fields.

I extend heartfelt thanks to our contributors and reviewers for their invaluable contributions. As future issues culminate, I urge readers and scholars to join us in this exploration to shape the future of engineering and technology.

Dr. R. C. Jaiswal

Journal Coordinator - PIJET
Associate Professor
Department of Electronics and Telecommunication
Pune Institute of Computer Technology, Pune, India.

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Reviewers

INDEX

Pneumatic end-effector for precise seeding

Piyush Malpure[1] Hrishikesh Chowkwale[2] Abhishek Gore[3] Aumkar Inamdar[4]Kunal Kale[5] Vaishali Gongane[6]
[1,2,3,4,5,6] Pune Vidyarthi Griha's College of Engineering and Technology &
G. K. Pate (Wani) Institute of Management, Pune, India

[1]malpurepiyush07@gmail.com, [2]hchowkwale@gmail.com, [3]goreabhishek396@gmail.com,
[4]auminam23@gmail.com, [5]kale.kunal4898@gmail.com, [6]vug_entc@pvgcoet.ac.in

Abstract

Robotics has brought a huge revolution in farming technology. Precision and accuracy are key features of robots. Automation in agriculture is an emerg-ing field that explores new and innovative techniques in farming. Robotic farming is a new research area which is attracting a lot interest. Precision farming is the area where this work focuses on gaining more yield, using opti- mum resources. The proposed system advances precise farming, leveraging a specially designed end-effector. The innovative device plays a crucial role in precise sowing of seeds for various plants. The efficacy of the end-effector has rigorously tested on vegetable seeds, mainly onion(light weight) and pumpkin seed (heavy weight), which form the ends of the seed weight spectrum. The end-effector incorporates a custom designed nozzle attached to the pneumatic actuator which can be changed according to the seed diameter. The nozzleis designed such that it is durable and sows the seeds precisely at required depths which are necessary for higher germination chances. An accuracy of 92% was obtained on pumpkin seeds and 93.34% on onion seeds with the designed end-effector.

Keywords:
Agriculture Robot, End-effector for seeding, Pneumatic end-effector,Precise seeding, End-effector

1. Introduction

A lot of research is being done in the field of agriculture. A lot of scien- tists are focusing on the development of techniques which will give high yieldof a particular crop. As the population rises the demand for food increases. Though the demand is increasing, land under cultivation is decreasing rapidly [1]. As the land under cultivation decreases more work needs to be done on the techniques which high quality yield per hectare. Many techniques have been researched by scientists to increase the crop yield, but the knowledge is not reaching the farmers in certain cases. Even if it reaches the adaptation rate is very low. The most effectively used technique is calledprecise farming [2].

Precise farming methodologies focus on growing quality and quantity of crop, thus giving high returns to the farmers. They take into consideration a lotof aspects, from seed weight and dimension to the final harvesting methods. Precise seeding is a sector where many aspects of sowing are to be considered, so that the final yield is obtained with minimum use of seeds. This kind of precision is difficult for humans to obtain over a longer time. Thus, involving robots is a valid choice to complete this task. This reduces human error and helps attain the desired precision [3][4].

2. Related Work

Agriculture robotics has been a domain where a lot of work is being donein the past couple of years. The most challenging part for robots in the agriculture domain is its diversity. Tough and robust designs are needed for successful implementation of robots. Work has been done by implementing aerial as well as ground robots for different tasks like seeding, weeding and harvesting [5].
In the domain of precise seeding, advantage can be taken of the already available precise industrial robots. The robotic arms are available in a large variety and are easily tunable to do a lot of tasks. With an effective design for end-effector this technology can be brought for mass use faster. The precision english seeder, a man operated seeder used for precise seeding in small areas, uses the pneumatic flow to pick up seeds with the help of a small needle tip attached to it. This type of structure can be made robust and automated for large scale use. Thus, we have focused on building an effective end-effector which can be adopted for a large variety of seeds. We have focused for itsuse on vegetable seeds.

Furthermore, the study done by Bracy et. al. [6] shows that the seed depth and spacing is of huge importance for increasing the yield. It also shows that the pneumatic suction on its own will not give great results, but when combined with other control techniques gives it a great advantage over othermethods. Thus, using precise robotic arms for precise seeding is bound to give good results.

3. Comparative Analysis

Most of the technologies which are used for sowing use huge machinery equipment. Most farming technologies use a tractor which is fit with the necessary modules, which are used for seeding. The tractors use grain drillsand planters. A variety of different types of such drills are already in use.These are heavy, bulky and costly modules [7].

Current robotic systems focus on the use of drill and belt seeders which are bulky [8]. Drill and belt seeders focus on speed rather than precision. Yanget. al. [9], have developed a precising smooth sowing robot which is also based on belt seeders. Lu et. al. [10], simulate a high-speed precise seeding device in lab, this system is comprised of large motors and gear system. A study shows that they also give a different performance for different types of seeds [11]. The review done by Nardon [12], showcases different requirements for different crops and the different types of systems which are used. Customizing the machine to give high performance for each type of crop is very difficult and costly as the complete system needs to be redesigned. Though itis easy to sow seeds on a large scale using faster components, many farmers use crop rotation and plant a variety of crops throughout the year, thesesystems then add up to his costs. The system design proposed, is easy to customize and adopt for a variety of crops. It also focuses on precision thus minimizing seed wastage.

4. Pneumatically Controlled Nozzle Design

Many factors go into deciding the design of the nozzle for seeding. Thesize and the surface area of the seed need to be taken into consideration so that only a single seed is picked up at a time. The depth at which a seedis sown also affects the chances of seed germination. A vegetable seed mustbe sown at least at a depth of 25mm for higher germination chances (This information was gathered from a survey done in College of Agriculture, Pune, India). The nozzle has a specially designed tip for different seed size and itstip extends down to the depth of 30mm thus providing the required depthfor sowing, thereby increasing the chances of germination.

The figure 1 shows proposed nozzle design. The hinder part of the nozzle is fixed to a vacuum pump permanently whereas the rest of the cylindrical part of the nozzle, which extends up to its tip canbe changed. This flexibility provides ease of changing the nozzle tips which come in different sizes and shapes, so that a variety of crops can be sownusing the same extruder. The two magnets hold in between them a thin fine-grained metallic filter thatfilters out the extra dust and sand which might due to some conditions enterupwards via the nozzle, thus blocking it and saving the pump from damage. The figure 2 shows a tip of diameter 5mm which can be used to pick upbigger seeds like pumpkin seeds. The figure 3 shows the nozzle with a tip diameter of 3mm which can be used to pick up small seeds like onion seed.

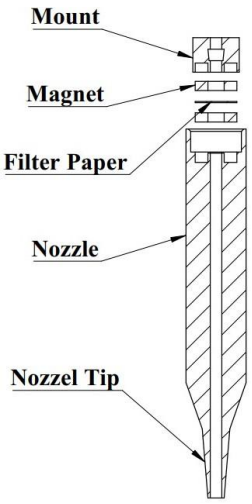

Figure 1: Exploded view of nozzle showing internal structure.

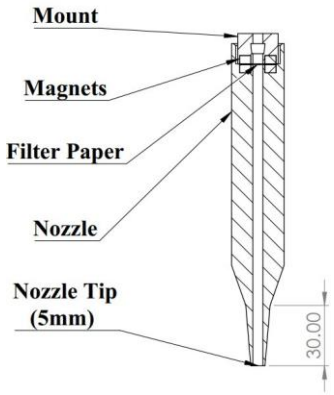

Figure 2: Nozzle with 5mm tip diameter for bigger seeds

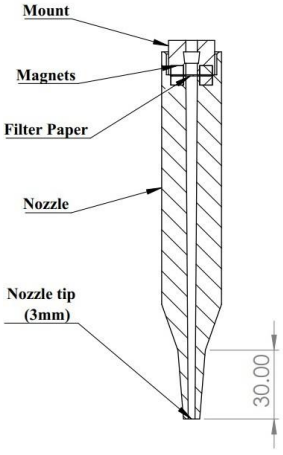

Figure 3: Nozzle with tip diameter to 3mm for smaller seeds.

5. Pneumatic End-effector

The nozzle is connected to a 12V vacuum pump by spark fun which provides a 15.1L of maximum flow capacity of air through it. The block diagram in figure 4 shows the connection for the vacuum pump. A 12V LiPo battery is connected to a DC motor driver, which has PWM control pins, using which speed of the suction pump motor can be varied. As the speed varies the flow velocity can be changed

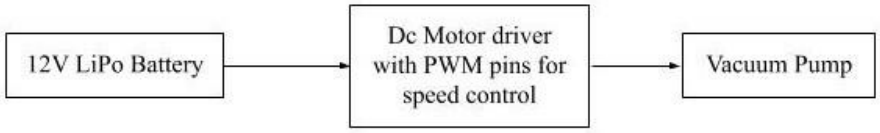

Figure 4: Block diagram for connection of vaccum pump.

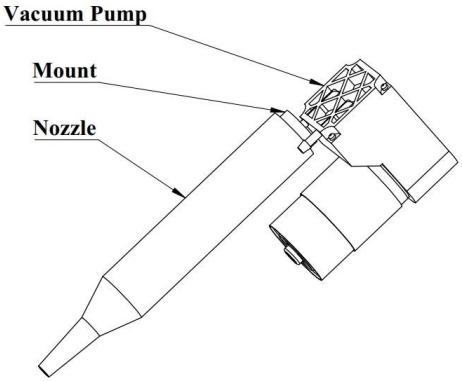

Figure 5: Nozzle mounted with suction pump.

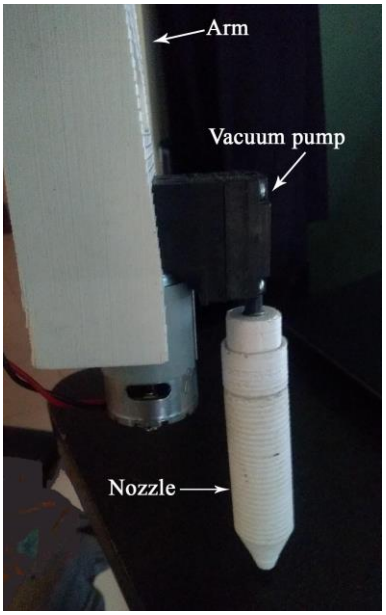

Figure 6: Actual constructed nozzle mounted with suction pump.

as per the requirements. This makesit ideal to be used for a variety of seeds. The complete end-effector assembly is as shown in the figure 5. The figure 6 shows the implementation of the assembly. Doing some simple calculations to check the capacity of the pump so thatit can be applied to a variety of crops with different weights, dimensions

andsurface area.

The calculations for determining vacuum pump parameters are as follows. Since most of the vacuum pumps can be decided based upon the flow rate(litre per minute), following steps are performed. Using the data regarding seed weight per unit, and nozzle diameter, preliminary required pressure can be obtained Table 1, shows the important and decisive steps in calculation. The concept followed during this calculation was based on primary physics. The pressure required was calculated using the weight of seed as load forceand area of nozzle tip as the pressure action area.

This pressure is caused due to the vacuum pump [14].

$$Pressure(Pa) = \frac{Weight\ of\ unit\ seed\ (kg)}{Cross\ Sectional\ Area\ of\ Nozzle\ tip\ (m^2)} \quad (1)$$

Using Bernoulli's equation [14],

$$P = \frac{1}{2}\rho v^2 + \rho g h = \text{Constant} \quad (2)$$

the pressure differential is acquired between the pump outlet and interface between nozzle and seed. Here considering the maximum datum difference during operation. Let P_1, v_1, h_1 be the values of Pressure, velocity of air and Height from datum, for plane containing seed-nozzle interface. Similarly, let P_2, v_2, h_2 be the values of Pressure, velocity of air and Height from datum, for plane containing pump outlet. Therefore, after modifying equation 2 optimally, according to the design requirement, following equation (3) is received,

$$\Delta P = \frac{1}{2}\rho v_2^2 + \rho g h_2 \quad (3)$$

Since h_1 is datum, and hence $h_1 = 0$. Also, since there can be no flow at seed-nozzle interface, $v_1 = 0$. Using Pressure from equation 1, and using itin equation 3, we get v_2. This velocity can be used to find out volume flowrate using area of cross section of nozzle tip.

Table 1 Flow rate calculation for pumpkin seeds (heavy weight)

Weight of seed [13]	0.208 *gram*
Diameter of nozzle	4.80 *mm*
Datum height difference	230 *mm*
Density of Air	1.225 kg/m^3
Pressure Difference required	112.76 Pa
Flow Velocity	13.7336 *m/s*
Flow rate	14.911 *litre/minute*

Table 2: Flow rate calculation for onion seeds (light weight)

Weight of seed [15]	0.003 *gram*
Diameter of nozzle	2.80 *mm*
Datum height difference	230 *mm*
Density of Air	1.225 kg/m^3
Pressure Difference required	4.7795 Pa
Flow Velocity	3.509 *m/s*
Flow rate	1.2965 *litre/minute*

Performing similar calculations for lighter and smaller seeds, like onion seeds. This shows that the system can be adopted to a huge variety of seeds.

6. Agricultural Seeding Robot

The above designed end-effector is then attached to an arm with 3 DegreesOf Freedom (DOF), which will act as a complete seeding system. The arm will then go to the pick-up location, the seed tray, the suction pump willstart, the seed then gets attached to the nozzle and then the arm takes itto the sowing location and lowers it into the soil. The nozzle reaches the required depth, once reached the suction pump is switched off and the seedis dropped in the soil. After this the arm is retracted and so the processrepeats itself in a loop. This arm is placed on a mobile robot which moves forward and stops at a particular interval of distance where the arm will sow the seeds at regular intervals. This ensures distance between two seeds and thus increases chances of germination of the seed.

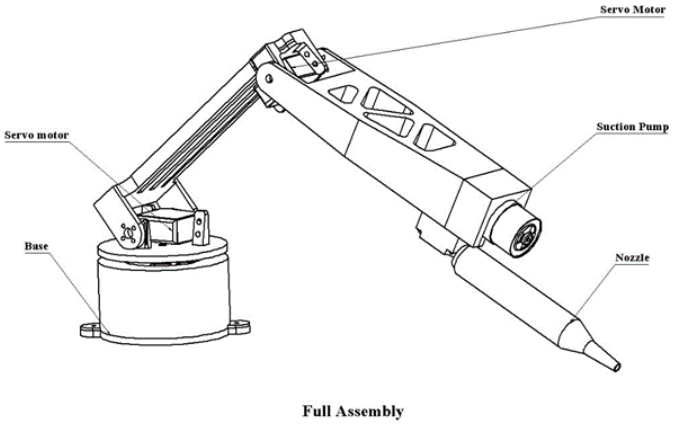

Figure 7: 3-DOF arm attached with the end-effector.

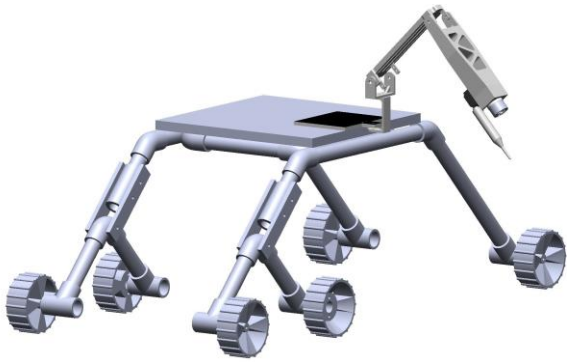

Figure 8: Complete rover shown in CAD model with the arm.

The arm structure shown in the figure 7 has been used to make the complete seeding system. Figure shows the end-effector connected to it.
This arm was mounted on a mobile robot, which was inspired by rocker bogie [16] mechanism. The complete assembly is as shown in figure 8. The rover can move over rough surfaces without any problem. The rover was designed for mars rovers and is open sourced by NASA [16]. With certain modifications to it, keeping the basic frame structure similar, this structurecan be thus used in the field of agriculture.

7. Results

After sowing 50 pumpkin seeds in the laboratory for testing the mecha- nism, it was found that 46 of them germinated, after observing the seeds for6 days after sowing. This gives an accuracy of 92% for heavy pumpkin seeds.30 onion seeds were also sown out of which 28 germinated on observing the seeds for 5 days after sowing. This gives an accuracy of 93.34% for light onion seeds. Giving the system an overall accuracy of 92.67%. This certainly givesan accuracy more than hand and tractor sowing seeds which has accuracy of upto 65 to 75% (This value of

accuracy was given by professors from Collegeof Agriculture, Pune, India).

Table 3 shows comparison of the pneumatic end effector system with other commonly used systems, with different parameters. The system doesn't just offer high accuracy but also provides easy and cost effective, customizable design. With use of more precise and faster industrial arms the speed of the whole system can surely be improved.

Table 3: Comparison with different systems.

	Tractor	Drill and belt seeder	Pneumatic seeder
Speed	High	Medium	Low
Precision	Low	Medium	High
System Size	Very Bulky	Very Bulky	Handy
Customization complexity	Very High	High	Low
Cost of customization	Very High	High	Low

8. Conclusion

Vacuum precision seeder provides better accuracy and high germinationchances, with the use of such an end effector. This thus provides 92.67% chances of germination. With the flexibility and ease of nozzle design, this provides a cost-effective solution that can be implemented on a wide variety ofseeds. It also provides great reliability for a wide variety of seeds. Onion seeds are very small and have light weight while the pumpkin seeds are large in sizeand are heavy. With good results for both far ends of the spectrum it showsthat it can give good results for the large variety of seeds by just changing thenozzle easily. Thus, ease of customization, with good germination accuracy, at low costs is attained in comparison with other systems. Using the extruderwith mobile robotic arms this can be adapted to a variety of environments, from small greenhouses to large farms.

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Optimizing Single Image Super-resolution and upscaling for resource-constrained computing environments

Tanveer Patil [1], Tanuja Khatavkar[1], Vaishali Gongane[1]

[1]Department of Electronics and Telecommunication, Pune Vidyarthi Griha's College of Engineering and Technology & G K Pate (Wani) Institute of Management, (ENTC), Pune, Maharashtra, India, tanveersantosh30@gmail.com, tsk_entc@pvgcoet.ac.in, vug_entc@pvgcoet.ac.in

Abstract

This research tackles the challenge of democratizing deep learning, focusing specifically on Single Image Super Resolution (SISR). In response to the inherent exclusivity stemming from high computational demands, this study introduces an optimized approach that harnesses the power of sub-pixel convolution networks. Specifically designed for everyday desktop GPUs, our methodology emphasizes computational efficiency and resource optimization, enabling the implementation of SISR without the need for specialized hardware. This work contributes to the broader mission of democratizing AI by optimizing the Efficient Sub-Pixel Convolutional Network (ESPCN) model for a standard PC with modest specs. The goal was to achieve a PSNR between 24-30 dB, surpassing traditional interpolation methods. The model was scaled to attain a PSNR of 27.98 for 1000 images and maintained a high value of 27.88 for 2500 images. This demonstrates the model's superior performance on resource-constrained PCs, bridging the gap between advanced AI and everyday computing.

1. Introduction

DEEP learning (DL) [1] is a branch of machine learning algorithms that aims at learning the hierarchical representations of data. Deep learning has shown prominent superiority over other machine learning algorithms in many artificial intelligence domains, such as computer vision [2], speech recognition [3], and natural language processing [4]. Super-resolution (SR) refers to the task of restoring high resolution images from one or more low-resolution observations of the same scene. According to the number of LR images, the SR can be classified into single image super resolution (SISR) and multi-image super-resolution (MISR) [5].

Image processing is the application of procedures to an image in order to enhance it or derive useful information from it. It is a type of signal processing where an image is supplied; and the output is either the picture or its characteristics/features [6]. One of the most well-known issues in the field of computers is Single Image Super-Resolution. It is particularly challenging to obtain a high-resolution image from its low-resolution equivalent when there is little to no information available. For this reason, deep learning models are mostly trained on big data sets and high-end computers. The ability of deep learning to absorb synthetic data and perform well during reconstruction has long been demonstrated. In this study, the primary objective centered on democratizing access to Image Super Resolution (ISR) by fine-tuning a Deep Learning Image Upscaling AI Model to operate efficiently on low to mid-specification personal computers. In this study, we present a Deep Learning model for Single-Image Super-Resolution that can up sample an input image with low resolution by a factor of three. In order to accomplish this, we will be utilizing a relatively standard personal computer system with an NVIDIA GTX 1650 and an Intel Core i5-9300H. In this research, we use the Deep Learning method of Efficient Sub-Pixel Convolutional Neural Networks (ESPCN) to increase the resolution of a given Low Resolution (LR) Image by up to 3 times (a satisfactory PSNR value in the range of 24dB to 30dB for 2,048 x 1,080-pixel images) and achieve a High Resolution (HR) Image while attaining better performance as compared to the classical Interpolation approach.

2. Related Work

The project draws inspiration from three websites (https://waifu2x.udp.jp/, https://letsenhance.io/ and https://github.com/bloc97/Anime4K), each reflecting the growing popularity of anime as a form of entertainment.

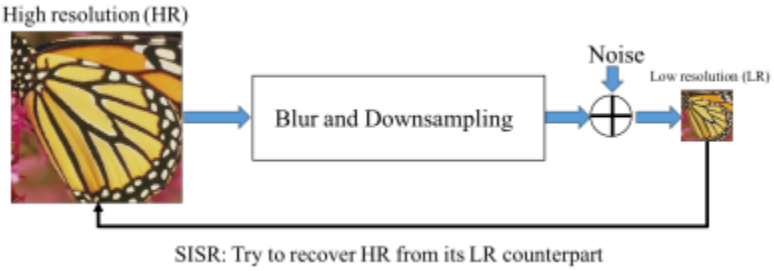


Fig. 1 Sketch of the overall framework of SISR [5]

Despite this surge in interest, existing platforms often fall short in meeting widespread demand, leading to compromises in picture quality. A notable solution to this challenge surfaced through our discovery of Anime4k, a real-time quality enhancer. Recognizing the broader implications of image and video quality limitations, not only in entertainment but across various sectors, we identified a significant gap in the medical field. In a realm where image processing remains at a nascent stage, particularly in critical areas like healthcare, we believe that the quality of visual data should not be a hindrance to delivering world-class treatment. Consequently, our research focus shifted to Single Image Super-Resolution (SISR), aiming to address these pivotal concerns. The framework of SISR is shown in the Fig. 1.

ESPCN, or Efficient Sub-Pixel Convolutional Network, is a method employed in super-resolution tasks, particularly in the realm of image processing. This technique is characterized by its post-up sampling approach, where feature extraction is conducted in a lower resolution space. The distinctive feature of ESPCN lies in its utilization of sub-pixel convolution, a method that replaces traditional deconvolutional layers. This substitution optimizes the up-sampling process, enhancing computational efficiency and contributing to the overall effectiveness of the super-resolution model. Several models underwent careful consideration before the selection of the ESPCN model. The decision-making process involved a thorough evaluation of various contenders, each scrutinized for its strengths and limitations. The intricate comparison of these models played a crucial role in identifying the ESPCN model as the optimal choice for our specific requirements.

The enhancement of the quality of an image can be at times very subjective depending on the viewer's perspective. Which method provides the best results when it comes to image enhancement can vary from person to person as an opinion. Therefore, it is quintessential to establish an empirical measure to compare the effects of enhancement algorithms on various images and the quality of the image. In this project, we propose a similar quantitative measure- Peak signal-to-noise ratio (PSNR).

The term peak signal-to-noise ratio (PSNR) [5] is an expression for the ratio between the maximum possible value (power) of a signal and the power of distorting noise that affects the quality of its representation. Because many signals have a very wide dynamic range, (ratio between the largest and smallest possible values of a changeable quantity) the PSNR is usually expressed in terms of the logarithmic decibel scale. PSNR is one of the ideal ways to quantify the reconstruction quality of images subject to irreversible compression from data encoding. Typical values of PSNR are between 30-50dB, for a bit depth of 8-bits.

The formula for PSNR is as follows:

$$MSE = \sum_{M,N} \frac{\{I_1(M,N) - I_2(M,N)\}^2}{M \times N} \quad (1)$$

M and *N* are the number of rows and columns in the input images.

To calculate the PSNR:

$$PSNR = 10 \log_{10} \left(\frac{R^2}{MSE} \right) \quad (2)$$

In equation (2), *R* is the maximum fluctuation in the input image data type. For example, if the input image has a

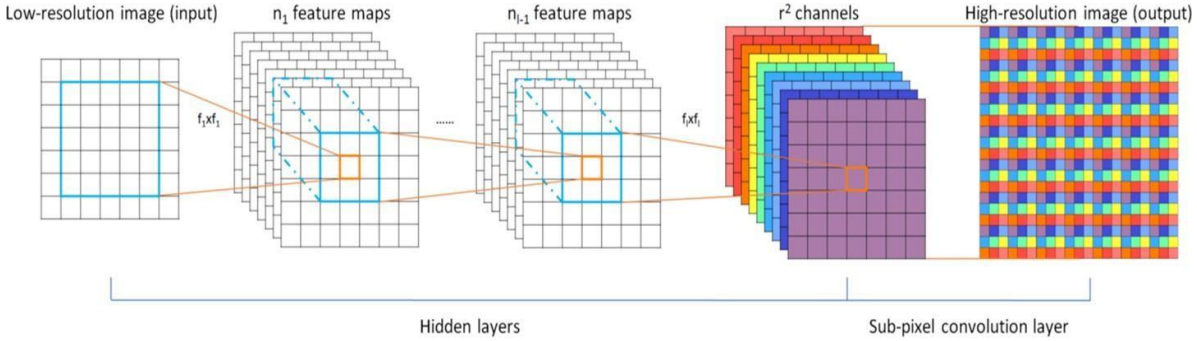


Fig. 2 Sub Pixel Convolution [5]

double-precision floating-point data type, then *R* is 1. If it has an 8-bit unsigned integer data type, *R* is 255. Different approaches exist for computing the PSNR of a color image. Because the human eye is most sensitive to luma information, you can compute the PSNR for color images by converting the image to a color space that separates the intensity (luma) channel, such as YCbCr. The Y (luma), in YCbCr represents a weighted average of R, G, and B. G is given themost weight, again because the human eye perceives it most easily. Compute the PSNR only on the luma channel. Both MSE (Mean Square Error) and PSNR are used to compare the quality of reconstructed images. MSE represents the cumulative squared error between the reconstructed image and the original image. The lower value of MSE indicates that the error is low. Yhang et al. [5] succinctly reviews recent deep learning advances in Single Image Super-Resolution (SISR). It categorizes works into architecture simulation and optimization objectives, highlighting limitations and presenting representative solutions. The paper concludes with insights into current challenges and future trends in SISR, emphasizing the superior precision of deep learning over traditional methods. Sub-pixel convolution works by converting depth to space, as seen in Fig. 2. Pixels from multiple channels in a low-resolution image are rearranged to a single channel in a high-resolution image. To give an example, an input image of size 5×5×4 can rearrange the pixels in the final four channels to a single channel, resulting in a 10×10 HR image. [5] A similar process of sub-pixel convolution takes place with the input PNG image where the image is upsampled by a factor of 3. The processed image is the plot into a graph for further comparison with the original image as well as with a similar image obtained by performing Bicubic Interpolation. Table 1

Yogeshvari et al. [10] explores the efficient Super-Resolution Convolutional Neural Network (SRCNN) and extends to various networks, including Generative Adversarial Networks (GAN). It emphasizes the balance between quality and speed but notes the impractical training demands of SRCNN and SRGAN due to high computational needs.

Table 1 compares the PSNR values in dB of the models on various datasets. This work in [13] focuses on a Generative Adversarial Network (GAN) Deep Learning Model with a sophisticated perceptual loss function. The model, capable of inferring photo-realistic images for 4x upscaling, emphasizes the preservation of fine textures.

3. Experimentation details

ESPCN (Efficient Sub-pixel Convolutional Network) which is a post-up sampling Super-resolution method is proposed. In post-up sampling, feature extraction is done in the lower resolution space. This reduces the computation

significantly as up sampling is only done at the end. Thus, the ESPCN model implements a sub-pixel convolution method which is used to replace the deconvolutional layers. During the evaluation, a publicly available benchmark datasets including the Timofte dataset widely used by SISR papers [7, 8, 9] which provides source code for multiple methods, 91 training images and two test datasets Set5 and Set14 which provides 5 and 14 images is used.
The Berkeley segmentation dataset BSD300 and BSD500 which provides 100 and 200 images for testing and the super texture dataset which provides 136 texture images. For our final models, we use 50,000 randomly selected images from ImageNet for the training. Following previous works, we only consider the luminance channel in YCbCr colour space in this section because humans are more sensitive to luminance changes. For each upscaling factor, we train a specific network [5]. The specifications of our system for implementation of ESPCN model is shown in Table 2. Table 2 provides details on the ASUS ROG Strix G531GT laptop, featuring an Intel Core i5-9300H processor (4 cores, 8 threads, 2.40GHz base frequency, and benchmark scores of 949/3307 in Geekbench 5). Additionally, it includes information on the NVIDIA GPU with 896 CUDA cores, a boost clock of 1545MHz, and 4GB GDDR5 VRAM.

Table 1 Model Comparison Chart [5]

Dataset	Scale	Bicubic	SRCNN	TNRD	ESPCN
Set5	3	30.39	32.75	33.17	33.13
Set14	3	27.54	29.30	29.46	33.13
BSD300	3	27.21	28.41	29.46	28.54
BSD500	3	27.26	28.48	29.46	28.64
Super Texture	3	25.40	26.60	26.66	26.70

Table 2 Specifications of the system

Name	Vendor	Specification
System Notebook Type: Laptop	ASUSTek Computer Inc	Asus ROG Strix G531GT(8Gb)
CPU (Cores, Threads, MaxFreq, Benchmark)	Intel	Intel Core i5-9300H, 2.40 GHz, 4 Core 8 Thread, 4100Mhz (Single Core / Multi-Core): 949/3307 [Geekbench 5]
GPU (Cuda Cores, BoostClock, VRAM)	NVIDIA	Cuda Cores: 896, Boost Clock: 1545 Mhz, VRAM: 4Gb GDDR5

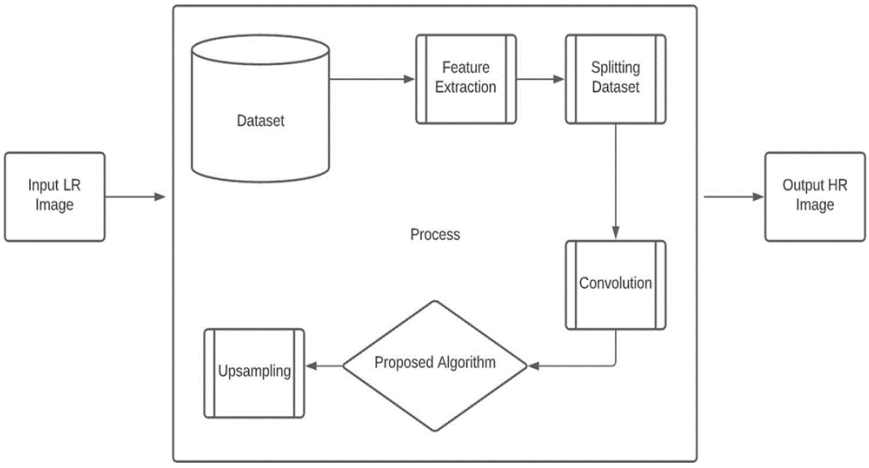


Fig. 3 Block diagram of the proposed system

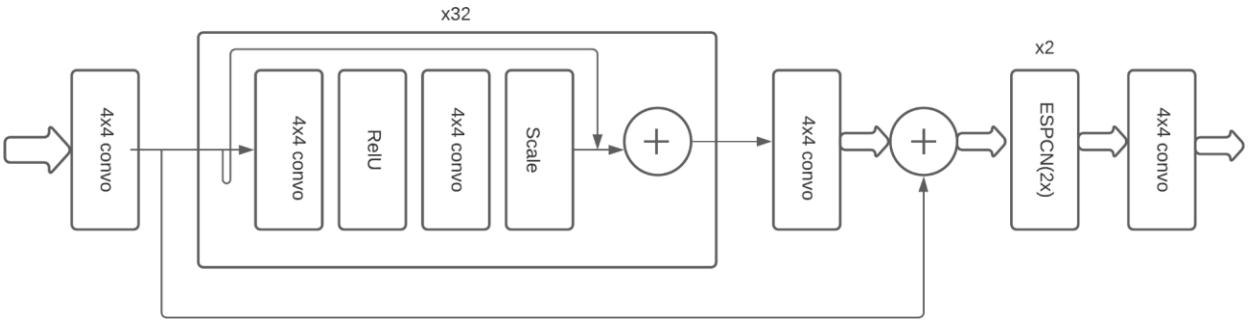


Figure 4: Block Diagram of the Algorithm

As shown in Fig. 3, the first block is the input block where the user will upload a Low-Resolution image for upscaling. The format of this image is in .png format for further processing. The second block of the image is the most crucial part, and this is where all the processing takes place. In this block, the images are stored in the database for further processing. This is then fed to the Deep Learning algorithm which then extracts the features of the image and further processing takes place. The proposed algorithm is the ESPCN algorithm which uses post-up-sampling for computing. In the next block, we split the given dataset for training and validation. As the concerned dataset contains 1000 images, we have split 800 images for training and 200 images for validation. The given image is then processed and up sampled. The output block gives the user a PNG image that has been upscaled by a factor of 3 and can be downloaded.

The proposed algorithm is depicted in Fig. 4 which is an ESPCN algorithm. In this algorithm, we have used 3 Convolutional layers for sub-pixel convolution and instead of adding deconvolution, we have replaced that layer with the layer of up sampling. This happens thrice and hence the image is upscaled by a factor of 3. The up-sampling process in the algorithm exclusively enlarges the image at its final stage, resulting in a high-resolution output. This strategic approach, performing up-sampling only once in the concluding phase, significantly reduces computational demands by employing small-size feature maps throughout the network. The ESPCN Model, trained on the D2FK Dataset, utilizes 3450 high-resolution images with a resolution of 2,048 x 1,080 pixels (termed "2K"). This dataset is meticulously divided into training (2760 images), testing (345 images), and validation (345 images) subsets. Specifically designed to foster research in realistic image super-resolution challenges, the D2FK Dataset introduces scenarios of degradation. Moreover, the ESPCN model enhances computational efficiency by incorporating a sub-pixel convolution method, effectively replacing deconvolutional layers for up-sampling. This approach not only

optimizes efficiency but also mitigates the checkerboard issue associated with conventional deconvolution methods. Table 3 shows the parameters of the image considered for experimentation.

Table 3 Image Parameters

Parameter	Specification
Input Image type	PNG (image/png)
Output Image	PNG (image/png)
Training Image Dataset	DIV2k Image Dataset
Dataset Size	10 Gb
Dataset Division	For Training: 800 Images. For Testing: 100 Images. For Validation: 100 Images.
Training Dataset Image Resolution	2048 x 1080 px
Upscale Factor	3

4. Results

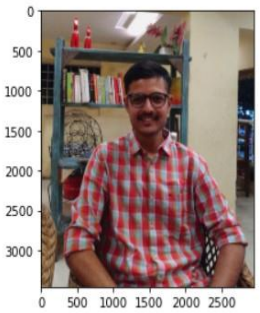
During the duration of Phase-I, we were successfully able to train the ESPCN Deep Learning Model. The model was trained, tested, and the validation, all was done and completed using the DIV2K image dataset. The PSNR of the generated image, when done in Google Colab, was found out to be 27.881190. We trained this model on 17x17 patches of the HR images. The original resolution of these images was 2048x1080px. The training loss at the first epoch was found out to be 0.0043 but later dropped to 0.0028 on the final epoch (Epoch-50). A total of 332 minutes was required to train the entire ESPCN Model on the Google Colab Notebook along with the use of the GPU provided. The PSNR of the generated image, when done on the Native machine, was found out to be 27.981799. We trained this model on 28x28 patches of the HR images. The original resolution of these images was 2048x1080px. The reason for the increase in the size of the patch of the image was the availability of greater computational power compared to Google Colab Notebook. Due to this, we were able to exploit the on-system GPU and increase the number of epochs to 60. The training loss at the first epoch was found out to be 0.0051, which was considerably high compared to the Colab Notebook, but later dropped to 0.0028 in the final epoch (Epoch-60). A total of 212 minutes was required to train the entire ESPCN Model on the native system. JupyterLab was also interfaced with the on-system GPU using the NVIDIA CUDA TOOLKIT and the CUDNN Tool. Table 4 compares the performance of ESPCN on three different hardware configurations. Fig. 5 shows the improved PSNR of test image. Table 5 compares the various parameters for three configuration of hardware.

Table 4 Results

Sr.	Parameters	Google Colab	Native System	Native System-1
1	PSNR of Test Image [HR](dB)	27.881190	27.981799	27.88123
2	PSNR of Test Image (Bicubic Interpolated) (dB)	27.474722	27.475621	27.457621
3	Image Resolution(px)	2048x1080	2048x1080	2048x1080
4	Training done on Image Patches (pixels)	17x17	28x28	32x32
5	Loss in the first Epoch	0.0043	0.0051	0.0044
6	Loss in the final Epoch	0.0028	0.0028	0.0030
7	Time taken to train the model(min.)	332	212	1042

```
In [4]:
1 from matplotlib import pyplot as plt
2 plt.imshow(cv2.cvtColor(HR_image, cv2.COLOR_BGR2RGB))

Out[4]: <matplotlib.image.AxesImage at 0x213d867cb20>
```




```
In [5]:
1 print("PSNR of ESPCN generated image: ", PSNR(cropped, HR_image))

PSNR of ESPCN generated image:  28.15214390009856
```

Fig. 5 Generated HR Image With a PSNR of 28.1521430000

Table 5 Value Look-up table for Software testing

Parameters	**(Google Colab)**	Native System-1	Native System-2
Epoch-1 Time	397s	288s	1036s
Epoch-1 Loss	0.0043	0.0051	0.0044
Epoch-1 PSNR	26.9361	26.0036	26.7721
Epoch-60 Time	398s	211s	972s
Epoch-60 Loss	0.0028	0.0028	0.0030
Epoch-60 PSNR	32.0210	31.5154	30.3192
PSNR of Test Image (HR)	27.8811	27.981799	28.1521439
PSNR of Test Image (Bicubic Interpolated)	27.4747	27.475621	26.875621

5. Conclusion:

In summary, our project successfully implemented a Deep Learning Model for Image Enhancement and Super Resolution, achieving the targeted upscale factor of 3. Our initial phase involved a comparative analysis between the ESPCN Model and a traditional Interpolation method. Notably, our experimentation yielded a notable Peak Signal-to-Noise Ratio (PSNR) of 27.981799 across a batch of 1000 images, each sized at 2048x1080 pixels. The project involved acquiring both theoretical and practical insights, identifying the necessary infrastructure, and seamlessly translating theoretical knowledge into practical application. Notably, we observed a substantial improvement in PSNR by 0.100609, indicating enhanced image quality, and a significant reduction in the model's training time by 120 minutes. As a pivotal advancement, our subsequent optimization endeavors enabled the seamless upscale to 2500 images of identical dimensions (2048x1080 pixels), all while consistently maintaining a commendable PSNR performance of 27.88123. This accomplishment was achieved while rigorously adhering to the specified computational constraints inherent in the designated PC hardware specifications. These outcomes underscore the technical success and efficiency gains achieved through the project's development and implementation phases. The future of single-image super-resolution involves advancements in deep learning architectures, attention mechanisms, real-time applications, and domain-specific approaches. Adversarial training, transfer learning, and multimodal integration are key focuses. Improved evaluation metrics, ethical considerations, and user interaction are also important aspects shaping the field's evolution. Ongoing developments will continue to impact these trends.

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MUSICAL FREQUENCY NOTE DETECTION

Kaustubh Joshi[1], Manish Godbole[2], Aditya Kadu[3], Rekha Kulkarni[4], Mukta Takalikar[5]

[1] Pune Institute of Computer Technology, Computer Engineering, Pune, Maharashtra, India, knj621311@gmail.com
[2] Pune Institute of Computer Technology, Computer Engineering, Pune, Maharashtra, India, manishgodbole02@gmail.com
[3] Pune Institute of Computer Technology, Computer Engineering, Pune, Maharashtra, India, adityakadu1203@gmail.com
[4] Pune Institute of Computer Technology, Computer Engineering, Pune, Maharashtra, India, rakulkarni@pict.edu
[5] Pune Institute of Computer Technology, Computer Engineering, Pune, Maharashtra, India, mstakalikar@pict.edu

Abstract
Accurate and rapid detection of musical notes is essential for tasks such as automatic tuning, transcription, and instrument recognition. Our intended work employs detector which uses advanced signal processing techniques to analyze audio input and determine the fundamental frequency (pitch) of the predominant musical note being played.
The system utilizes a combination of time-domain and frequency-domain analysis to extract relevant features from the input audio signal. These features are then fed into a machine learning-based classifier that identifies the closest musical note corresponding to the detected frequency. To ensure adoptability and accuracy, the system has been trained on a comprehensive dataset covering a wide range of musical instruments, playing styles. Our work presents the design, implementation, and evaluation of a novel musical frequency note detector aimed at instrumental applications in varied musical contexts.

Keywords: *Audio input, Fundamental frequency, Pitch, Time-domain, Frequency-domain, Novel musical frequency note detector.*

I. INTRODUCTION

Music, a global medium that bridges geographical and cultural divides, has consistently been a focus of intrigue and research. The capacity to dissect and comprehend music's subtleties, such as identifying individual musical notes within a piece, has extensive implications in areas from music theory and pedagogy to audio processing and digital signal examination. This research article ventures into the sphere of musical frequency note detection, a vital field of study in music technology. By investigating the principles and methodologies underlying this process, we aspire to illuminate the fundamental mechanics of musical notes, their frequencies, and how cutting-edge technology can aid their accurate identification. In doing so, we anticipate opening of new pathways for creativity, education, and innovation in the music domain.

II. LITERATURE REVIEW

Akhilesh Sharma, et al. [1], have studied about music information retrieval, focusing on Indian Classical music and its two major parts. Authors have used classification methods like Mel frequency cepstral coefficients (MFCCs) and spectrograms.
It considers the computational techniques applied to understand the heritage of Indian Classical Music, highlighting the distinct characteristics of Hindustani and Carnatic traditions. It explores the complexity of Carnatic Music, emphasizing the significance of Ragas and Talams. The paper concludes by examining the fundamental elements of Indian Classical Music, such as musical notes, intervals, and scales, highlighting the unique aspects of Hindustani and Carnatic traditions.

Artificial neural networks have witnessed three notable waves: the perceptron algorithm (1957), backpropagation algorithm (1986), and the deep learning success in 2012. Hendrik Purwins et al. [2], have extensively studied Deep learning networks including architectures like deep feedforward neural networks, convolutional neural networks (CNNs), and long short-term memory (LSTM). Due to a focus on audio signal processing, this wave has surpassed traditional

methods, particularly in image, speech, music, and environmental sound processing. While looking at image processing, audio has unique challenges due to its one-dimensional time series nature. The shift to deep learning in several domains, has outperformed conventional models where ample data is available.

As per the work by Jay K. Patela et al. [6], A song contains basically two things, vocal and background music. Where the characteristics of the voice depend on the singer and in case of background music, it involves mixture of different musical instruments like piano, guitar, drum, etc. To extract the characteristic of a song becomes more important for various objectives like learning, teaching, composing. The experiment is done with the several piano songs where the notes are already known, and identified notes are compared with original notes until the detection rate goes higher. And then the experiment is done with piano songs with unknown notes with the proposed algorithm.
The article by John Glover et al. [7] provides a review of some of the most used techniques for real-time onset detection. The authors suggest ways to improve these techniques by incorporating linear prediction as well as presenting a novel algorithm for real-time onset detection using sinusoidal modelling. As well as provides comprehensive results for both

the detection accuracy and the computational performance of all the described techniques, evaluated using Modal.

In the research by Allabakash Isak Tamboli et al. [8], the authors developed a musical note recognition method based on an optimization-based neural network (OBNN) within a classification framework. The study involved an extensive review of existing approaches for musical note recognition. The use of OBNN for recognizing musical notes was explored. The document comprehensively analyzes recent investigations related to musical note recognition, summarizing their findings and classifications, with the aim of advancing the effectiveness of this recognition process through diverse methodologies.

The paper by Smith Julius O. [3] gives seminal work in the field of digital audio processing. This paper delves into the principles and methodologies of physical modeling, which simulates the behavior of real-world musical instruments and sound effects in the digital domain. It explores the mathematical and computational foundations of physical modeling, allowing for the creation of highly realistic virtual instruments and audio effects. By emphasizing the accurate emulation of physical interactions and acoustic phenomena, Smith's research paper has been pivotal in advancing the quality and authenticity of digital music synthesis and audio processing. It remains a foundational reference for researchers and engineers in the field.

The paper by H Purwins et al. [2]. gives comprehensive overview of the application of deep learning techniques in the field of audio signal processing. It explores the use of neural networks and deep learning architectures for tasks such as speech recognition, music analysis, and sound synthesis. The paper discusses various deep learning models and their effectiveness in handling complex audio data. It serves as a valuable resource for researchers and practitioners interested in leveraging deep learning for advanced audio processing applications.

The authors of [4] present Critical problem of accurately estimating pitch in speech signals contaminated by noise. The authors propose a novel pitch estimation method tailored for noisy conditions, focusing on the challenging scenario of adverse environmental or recording conditions. Their approach combines adaptive filtering and signal processing techniques to enhance the accuracy and robustness of pitch estimation in the presence of noise. This paper presents an essential contribution to speech signal processing, particularly in contexts where noise interference poses a significant challenge, making it valuable for applications like speech recognition and enhancement.

The work by S. Wang et al. [5] senses self-supervised learning approach that leverages audio-visual data with spatial alignment to enhance audio representation learning. The proposed method combines visual information and audio signals

to train deep neural networks without explicit annotations. By exploiting spatial alignment cues, the model learns robust and informative representations, which have applications in areas such as speech and sound analysis, offering potential benefits for improving the accuracy of audio-based tasks using multi-modal data.

III. METHODOLOGY

In our proposed method we are using the combination of signal processing, and visualization for the analysis and comprehension of audio properties. Amplitude envelope is calculated to know about the peak amplitude within chosen frame sizes. To align the envelope with time for further visualization time and the frame calculations are done. The Short-Term Fourier Transform (STFT) is used to find time frequency characteristics of the audio. Pitch identification is done by tracking the peaks in the magnitude of STFT. Finally, the note mapping method is used in mapping frequencies to musical note. Following methods have been used as a part of our implementation.

1. **Audio Loading**: Audio Import: The code initiates by importing an audio file ('test.mp3') utilizing the librosa.load function, which results in the raw audio waveform and its sampling rate (SR). This action readies the data for further examination.

2. **Waveform Visualization**: It continues with the display of the audio waveform using Matplotlib. This display illustrates the amplitude of the audio signal as it progresses over time, offering a visual comprehension of the audio's attributes.

3. **Amplitude Envelope**: To scrutinize the signal's fluctuations, two functions, amp_env and fancy_amp, are employed to calculate the amplitude envelope. The amplitude envelope seizes the peak amplitude within designated frame sizes, a vital feature for a variety of audio processing tasks.

4. **Time and Frame Calculation**: The code begins by determining the time and frame indices for the amplitude envelope using the librosa.frames_to_time function. This step aligns the envelope with time for subsequent visualization.

5. **Visualizing the Envelope**: The code then generates another Matplotlib plot, which displays the audio waveform and overlays the amplitude envelope in red. This visualization aids in understanding the amplitude's temporal variations.

6. **Short-Time Fourier Transform (STFT)**: To delve into the audio's time-frequency characteristics, the code computes the STFT using `librosa.stft`. The STFT provides a detailed representation of the audio signal in the time and frequency domains.

7. **Pitch Detection**: For pitch analysis, the code uses the `librosa.piptrack` function to identify pitch frequencies in each frame. This process is achieved by tracking the peaks in the magnitude of the STFT.

8. **Note Mapping**: A dictionary, `note_mapping`, is defined to map detected frequencies to their corresponding musical note names, allowing for easier interpretation of the pitch information.

9. **Average Pitch Calculation**: The code calculates the average pitch within specific frame intervals to provide a more generalized view of the audio's pitch characteristics. It calculates the mean pitch, ignoring any NaN values in the pitch data.

10. **Displaying Results**: Finally, the code prints and displays the average frequency and corresponding musical notes for each set of frames at specified intervals.

Our system architecture diagram is depicted in the following Fig. 1

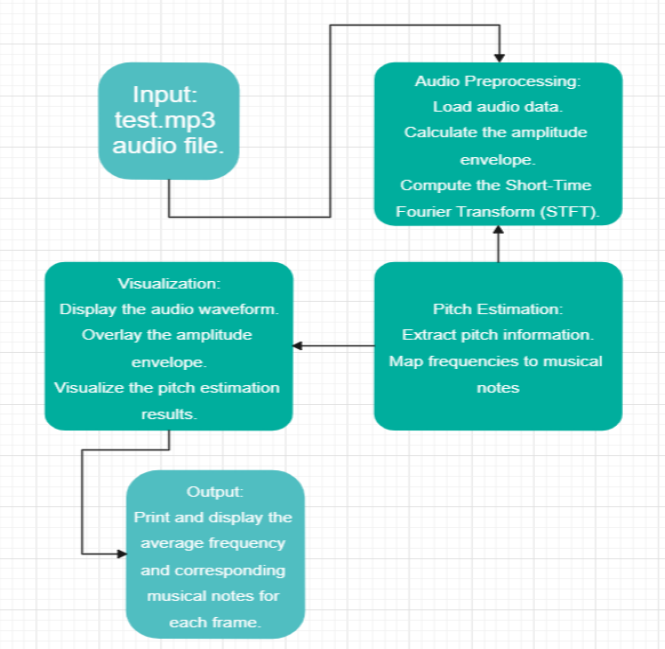

Fig 1 Proposed Architecture System

IV. IMPLEMENTATION

We integrate signal processing, visualization, and feature extraction techniques to analyze audio data, highlighting attributes such as amplitude variations and pitch characteristics in a structured and visually informative manner.

The methodology primarily relies on traditional audio analysis techniques and visualization, rather than machine learning models or classifiers.

V. RESULTS AND DISCUSSION

We have implemented our method for finding the musical notes for which following table shows some sample results.

Table 1: Sample Frequency and Corresponding Note

```
Average Frequency and Notes for Every 132 Frames:
Frames 1-132: 549.40 Hz, None
Frames 133-264: 557.13 Hz, None
Frames 265-396: 523.65 Hz, None
Frames 397-528: 434.92 Hz, A4
Frames 529-660: 445.90 Hz, A4
Frames 661-792: 393.01 Hz, G4
Frames 793-924: 409.39 Hz, G#4
Frames 925-1056: 377.58 Hz, F#4
Frames 1057-1188: 374.47 Hz, F#4
Frames 1189-1320: 298.26 Hz, D4
Frames 1321-1452: 400.85 Hz, G4
Frames 1453-1584: 452.31 Hz, None
Frames 1585-1716: 419.64 Hz, G#4
Frames 1717-1848: 312.35 Hz, D#4
Frames 1849-1980: 331.72 Hz, E4
Frames 1981-2112: 322.05 Hz, E4
Frames 2113-2244: 427.73 Hz, None
Frames 2245-2376: 337.00 Hz, E4
Frames 2377-2508: 313.32 Hz, D#4
Frames 2509-2640: 424.86 Hz, G#4
Frames 2641-2772: 317.97 Hz, D#4
Frames 2773-2904: 423.64 Hz, G#4
Frames 2905-3036: 367.24 Hz, F#4
Frames 3037-3168: 274.59 Hz, C#4
Frames 3169-3300: 347.83 Hz, F4
Frames 3301-3432: 574.12 Hz, None
Frames 3433-3564: 529.09 Hz, None
Frames 3565-3696: 502.88 Hz, B4
Frames 3697-3828: 430.95 Hz, A4
Frames 3829-3960: 429.46 Hz, None
Frames 3961-4092: 391.47 Hz, G4
```

Fast Fourier Transform (FFT) is a mathematical technique that transforms an audio signal into its frequency components. It's fast and efficient but requires a lot of memory and may not be suitable for real-time applications.

Librosa is a Python package for music and audio analysis. It's easy to use and offers a rich set of features for music analysis. However, it may not be compatible with some older versions of Python or operating systems.

Autocorrelation is a statistical measure that quantifies the similarity between a given time series and its lagged version. It can reveal hidden information in data but requires a lot of computation time and may produce misleading results if the data is non-stationary or has noise.

METHOD	PARAMETER	BEST APPLICATION
FFT	Frequency Resolution	Audio Signal Processing
LIBROSA	MFCC	Music Genre Classification
AUTOCORRELATION	Pitch Period	Speech Processing

APPLICATION TABLE

VI. CONCLUSION

The primary objective of this study is to comprehend the detection of musical frequency notes, highlighting the immense possibilities for application development and its significant influence on music and technology. The necessity for precise note detection spans various areas, including music education, transcription, and audio processing. Accurate note identification provides essential tools for musicians and learners, enhancing music teaching and learning, and allowing musicians to perfect their performances and compositions. Moreover, our research has demonstrated how advancements in technology, such as digital signal processing and machine learning, have streamlined and democratized automated note detection, paving the way for the creation of software tools and applications that assist musicians of all skill levels. In addition, our research emphasizes the critical need for meticulous investigation in this field, underscoring the importance of extensive and diverse datasets, sturdy algorithms, and the ongoing refinement of techniques to boost the precision and dependability of note detection systems. In essence, the goal of musical frequency note detection extends beyond the technical sphere, fusing creativity and education with technology. This harmonious integration of music and technology opens new avenues for articulating artistic work with learning. As we persist in refining and innovating, we envision a future where music becomes more accessible, lucid, simple, and enriched for everyone. This research uncovers the immense potential that awaits in the domain of musical note detection.

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Revolutionizing Skin Disease Classification with Machine Learning

Prathamesh Kokate [1], Sarthak Gojorekar [2] & Kalyani Waghmare [3]

[1]Student; SCTR's Pune Institute of Computer Technology, (Computer Engineering), Pune, Maharashtra, India, prkokate10@gmail.com
[2]Student; SCTR's Pune Institute of Computer Technology, (Computer Engineering), Pune, Maharashtra, India, sarthakgojorekar@gmail.com
[3]Assistant Professor; SCTR's Pune Institute of Computer Technology, (Computer Engineering), Pune, Maharashtra, India, kcwaghmare@pict.edu

Abstract:

Skin disease is a very common disease for humans. In the medical industry detecting skin disease and recognizing its type is a very challenging task. Due to the complexity of human skin texture and the visual closeness effect of the diseases, sometimes it is really difficult to detect the exact type. The most melanoma type of cancer if not detected in early stages, then it spread to other parts of the body very easily in no time. Therefore, it is necessary to detect and recognize the skin disease at its very first observation. In today's era, the use of artificial intelligence is rapidly growing in medical field. Different machine learning and deep learning algorithms are used for diagnostic purposes. These methods drastically improve the diagnosis and also speed up the process. In this paper the techniques like Convolutional Neural Network and OpenCV picture-handling techniques to recognize and classify various types of skin diseases are implemented. Dermoscopic images are considered as inputs in the pre-handling stages. A system that can analyze images and notify dermatologists of the existence of skin disease might potentially eliminate the need for a lot of manual diagnosis work. The result showed greater accuracy and promising signs that machine-learning algorithms can indeed assist in early identification of the disease and improvement of the treatment outcome.

Keywords: Classification, Convolutional Neural Network, OpenCV image handling, performance measures.

1 Introduction

In the current healthcare industry, the speedy development of technology has become critical for the detection and prognosis of various medical situations. This is mainly authentic for dermatology, in which identification of pores and skin sicknesses is essential for timely intervention and treatment. Although traditional treatment methods are often steeply-priced, time consuming, and sometimes painful, the combination of modern technology has provided a reliable alternative. Previous research on this area has centered on manual testing, which is situation to human mistakes and restrained via medical doctor talent. Although some attempts have been made to use photo processing techniques, the shortage of preferred techniques and the absence of a robust, available devices have avoided their sensible use. most of them focus on the binary classification problem. Often different types of skin pathologies are grouped into the same class and not classified. As an end result, there may be an obvious want for an automatic, reliable, and consumer-friendly system which could correctly diagnose diverse skin diseases at an early degree.

CNNs have gained widespread popularity and proven to be highly effective in various fields, including image recognition, natural language processing, and medical image analysis. Their unique architecture enables them to automatically extract relevant features from raw input data, making them particularly suitable for tasks such as image classification and object detection. In the context of dermatology, CNNs have demonstrated remarkable accuracy in identifying and categorizing various skin diseases based on visual cues and patterns. By processing large datasets of

skin images, CNNs can learn to discern subtle differences in textures, colors, and shapes, allowing for the precise classification of different skin conditions by using deep networks for feature extraction and prediction.

The field of dermatology has witnessed remarkable improvements in recent years, especially with the integration of Artificial Intelligence (AI) into classification and diagnosis of various skin diseases. This literature assessment targets to discover the big contributions made with the aid of various researchers in leveraging AI technologies for accurate and green prognosis and remedy of pores and skin diseases.

The study conducted by Keshetti Sreekala et. al. [1] demonstrated the use of Structural Co-occurrence Matrices (SCM) and an advanced Convolutional Neural Network (CNN) in achieving an impressive accuracy rate of 97% in classifying skin diseases. Their approach, incorporating robust preprocessing techniques and advanced deep learning models, significantly improved the quality of image analysis for skin disease classification. J. Samraj and R. Pavithra [2] emphasized the effectiveness of deep learning models, particularly Convolutional Neural Networks (CNNs), in facilitating the accurate and rapid diagnosis of various forms of skin cancer. Their study highlighted the role of image preprocessing techniques and the use of the ISIC 2018 dataset, showcasing the potential of deep learning algorithms like Resnet50, InceptionV3, and Inception Resnet in enhancing diagnostic accuracy, which achieved an overall accuracy rate of 85.7% in the detection of both benign and malignant forms of skin cancer.

Laura Pawlik, et al. [3] focused on the in development occurred in diagnosis and treatment in optimizing the clinical management of melanoma and non-melanoma skin cancer. Their research emphasized on the importance of precise classification and therapy decision-making, portraying importance of the innovative diagnostic techniques available for skin cancer management. Renato Marchiori Bakos et. al. [4] highlighted the significance of noninvasive imaging devices like dermoscopy, Reflectance Confocal Microscopy (RCM), and Optical Coherence Tomography (OCT) in improving the accuracy of skin cancer diagnosis in real-time. Their research emphasized the combination of RCM and OCT as the preferred technique for diagnosing suspicious lesions, enabling effective monitoring of treatment response and adjustments in therapy when necessary.

The work of Karl Thurnhofer-Hemsi et. al. [5] introduced a unique approach that integrated multiple deep-learning classifiers and utilized shifted images to enhance the classification of skin lesions. Their use of deep convolutional classifiers and regular shift patterns showcased the potential of combining the strengths of multiple classifiers to achieve more accurate results. These methods yielded 83.6% accuracy of detection and classification of skin diseases. Fawaz Waselallah Alsaade et. al. [6] demonstrated the effectiveness of a Computer-Aided Diagnosis (CAD) system for the detection of skin cancer, emphasizing feature-based and deep learning approaches using dermoscopy images. Their research highlighted the significant accuracy achieved by the Artificial Neural Network (ANN) model, showcasing the potential of CAD systems in improving the accuracy and efficiency of skin cancer diagnosis.

S. M. Chaware et al. [7], presented an innovative approach to automated skin disease diagnosis. Employing advanced methodologies such as Convolutional Neural Networks (CNN) and image processing algorithms, the system demonstrates high accuracy in recognizing and classifying diverse skin conditions. With its user-friendly interface, real-time diagnostic reports, and personalized recommendations, the proposed system represents a significant step forward in enhancing accessibility and efficiency in remote dermatological care. Kumar Abhishek et. Al. [8] proposed a deep semantic segmentation framework for dermoscopic images that incorporates information extracted using the physics of skin illumination and imaging. Their work focused on addressing challenges related to variations in lesion shape, size, color, and contrast to improve segmentation accuracy. Nawal Soliman et. al. [9] presented an image processing-based approach for detecting skin diseases. The method used a pre-trained CNN (AlexNet), and classification via SVM. Achieving a remarkable 100% accuracy rate, the system successfully identifies three types of skin diseases namely eczema, melanoma, psoriasis. A key emphasis is placed on image resizing for standardization, showcasing the efficiency and simplicity of the proposed system in diagnosing skin conditions, particularly in regions like Saudi Arabia where skin diseases are prevalent due to the hot desert climate.

For skin disease classification various standard datasets are available such as "Human Against Machine with 10000 training images" HAM10000 [10], PH2[11], and various versions of skin disease data archived by International Skin Imaging Collaboration (ISIC)[12, 13]. The archive of skin images is publicly available resource for teaching, research, and the development and testing of diagnostic artificial intelligence algorithms. In [14,15] authors presented challenges in ISIC 2017 and 2018 observed by ISIC in biomedical imaging dataset to improve the algorithm performance and generalize in medical domain.

Overall, the studies have showcased promising levels of accuracy, with a focus on the use of advanced CNNs and deep learning models, highlighting their effectiveness in improving the classification and diagnosis of skin diseases. However, challenges related to variations in lesion characteristics, including shape, size, and color, have posed obstacles to achieve consistent high levels of accuracy. Despite these limitations, the integration of non-invasive diagnostic tools such as optical coherence tomography (OCT) and Reflectance Confocal Microscopy (RCM) has demonstrated potential in enhancing the accuracy of skin cancer diagnosis in real-time, enabling informed treatment decisions.

2 Methodology

The work is divided in three modules Data Preparation, Model Training and Testing shown in fig. 1.1. Three different models are designed and trained. Models refer to the specific configurations of CNN architectures designed to analyze and classify skin lesion images. These models are essentially computational representations of the human decision-making process, built to process input data, extract relevant features, and make accurate predictions regarding the type of skin disease present in the images. Each model is composed of various layers, including convolutional layers, pooling layers, dense layers, and specialized layers such as BatchNormalization and Softmax activation layers.

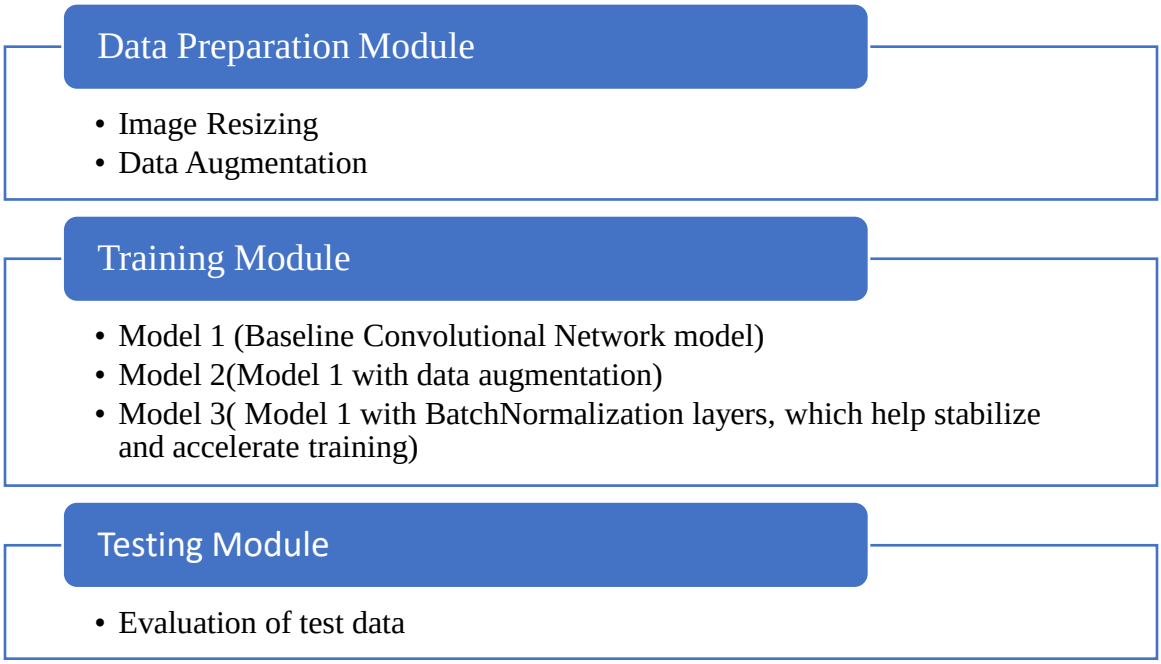

Fig. 1.1 System Design

In Data preparation module, the preprocessing is done on dataset. The skin cancer dataset from the "Skin Cancer (ISIC) 2020 The International Skin Imaging Collaboration."[16] is used for experimentation. It consists of a around

13K collection of images representing nine different classes of skin lesions. The class labels fig. 1.2 shows number of images in testing dataset from each class.

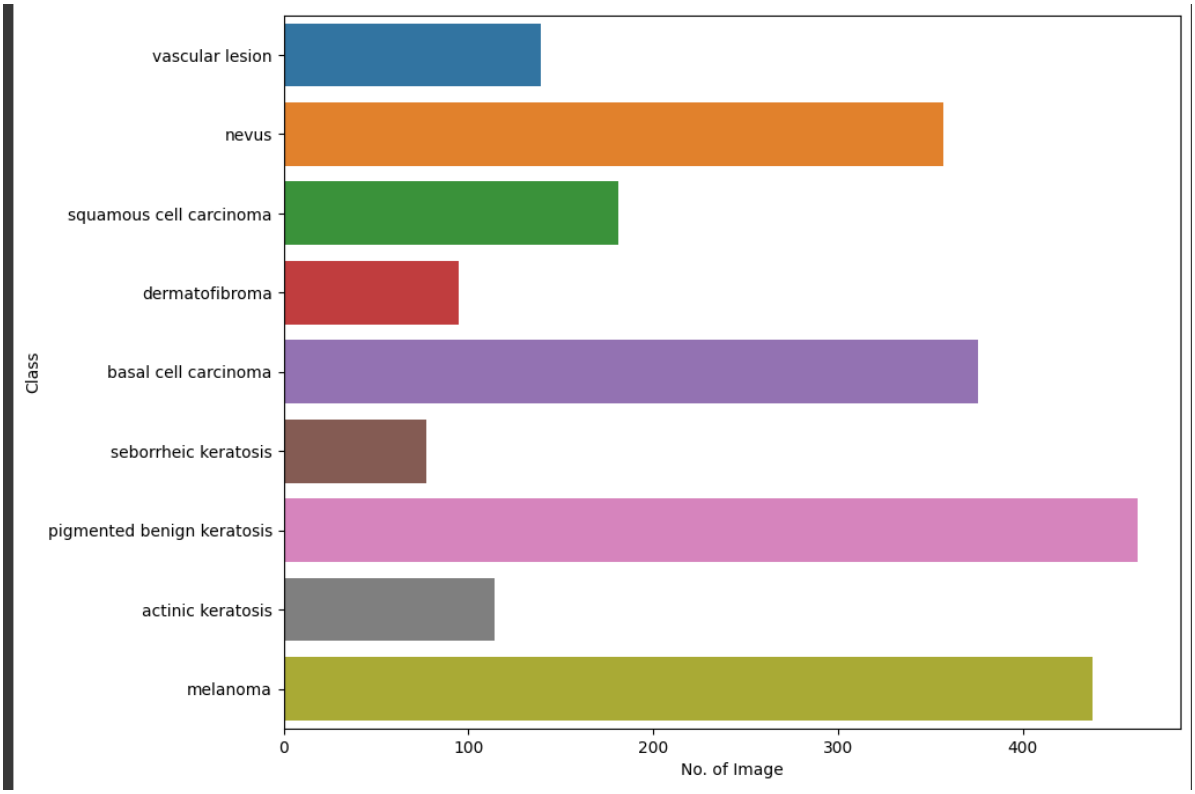

Fig 1.2 No. of samples of testing dataset from each class

The dataset is divided into a 80:20 ratio of training set and testing set. In fig 1.3 few samples from the dataset are shown.

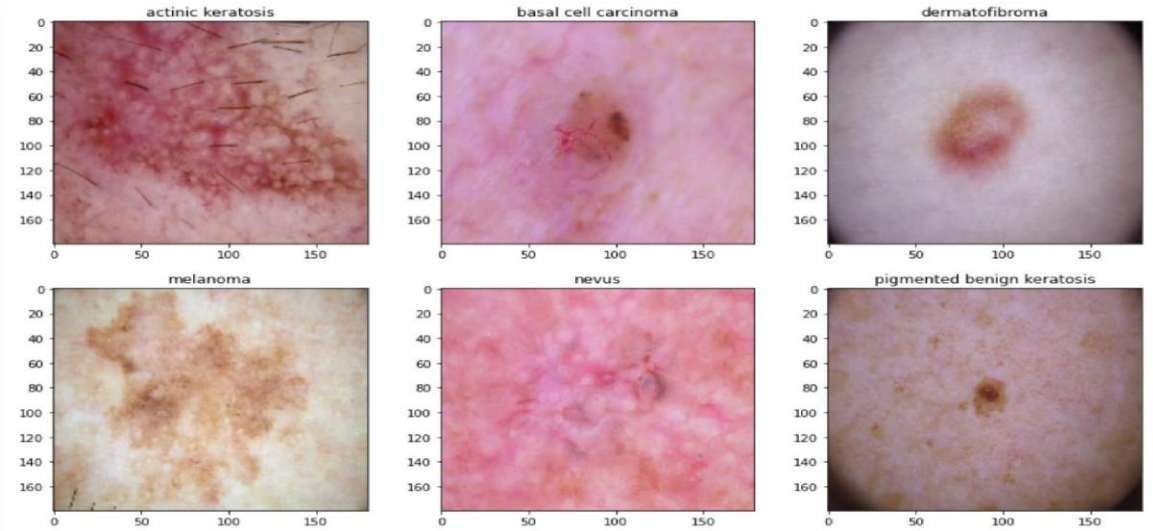

Fig 1.3 samples from the dataset

Data augmentation is done for increasing the diversity of the training dataset, which, in turn, enhances the model's generalization. The following data augmentation techniques were applied to the training images:

- Random horizontal and vertical flipping with a probability of 0.7.
- Random rotations with a maximum left and right rotation of 10 degrees.
- Random zooming with a zoom range of 20%.
- Random translations with horizontal and vertical shifts of 10%.

One sample after augmenting one image is shown in fig. 1.4

Fig 1.4 Augmented sample

The models are trained using the skin cancer dataset, which is prepared by dividing it into a training set and a validation set. During the training process, the models are exposed to the training dataset, and the parameters within the models are optimized using an optimizer. The training involves iterating through the dataset multiple times (epochs), during which the models learn to recognize patterns and features that differentiate different types of skin lesions. The performance of the models is continuously evaluated on the validation dataset, monitoring metrics such as accuracy and loss to assess their ability to accurately classify skin diseases. The training process aims to enhance the generalization and predictive capabilities.

The training is performed using three different models. Model 1 is a baseline convolutional neural network (CNN) architecture, consisting of several convolutional layers, max-pooling layers, and dense layers. It is designed to operate on the original training dataset.
Input shape: (img_height, img_width, 3)
Model 1 Architecture includes:

1 Convolutional Layer 1: 32 filters, kernel size (3, 3), ReLU activation
2 Max-Pooling Layer 1: Pool size (2, 2)
3 Dense Layer: 128 units, ReLU activation
4 Output Layer: len(class_names) units, Softmax activation
5 Training Parameters: Optimizer - Adam, Loss - Categorical Cross-Entropy

Layer (type)	Output Shape	Param #
rescaling (Rescaling)	(None, 180, 180, 3)	0
conv2d (Conv2D)	(None, 178, 178, 32)	896
max_pooling2d (MaxPooling2D)	(None, 89, 89, 32)	0
conv2d_1 (Conv2D)	(None, 87, 87, 64)	18496
max_pooling2d_1 (MaxPooling2D)	(None, 43, 43, 64)	0
conv2d_2 (Conv2D)	(None, 41, 41, 128)	73856
max_pooling2d_2 (MaxPooling2D)	(None, 20, 20, 128)	0
flatten (Flatten)	(None, 51200)	0
dense (Dense)	(None, 512)	26214912
dense_1 (Dense)	(None, 128)	65664
dense_2 (Dense)	(None, 9)	1161

Fig 1.5: Layers used in Model 1 in CNN

Model 2 is an improved version of Model 1, incorporating the augmented dataset. Data augmentation layers were added at the beginning of the model to leverage the augmented images.

1. Input shape: (img_height, img_width, 3)
2. Data Augmentation Layers
3. Model architecture (same as Model 1)
4. Training Parameters (same as Model 1)

Model 3 is another CNN architecture, similar to Model 1, but includes BatchNormalization layers, which help stabilize and accelerate training.

1 Input shape: (img_height, img_width, 3)
2 Rescaling Layer: Scales pixel values to the range [0, 1]
3 Model architecture:
4 Convolutional Layer 1: 32 filters, kernel size (2, 2), ReLU activation
5 BatchNormalization Layer
6 Output Layer: len(class_names) units, Softmax activation
7 Training Parameters: Optimizer - Adam, Loss - Categorical Cross-Entropy

Both the models were trained using the following training parameters:

- Batch Size: 32

- Number of Epochs: 20

The training process involved optimizing the models using the Adam optimizer with categorical cross-entropy loss, and evaluating their performance on the validation dataset. The training and validation accuracy and loss were monitored over epochs.

3. Results & Discussion

The implementation of the skin cancer classification models yielded significant results, showcasing the effectiveness of the developed methodologies. Model 1, serving as the baseline, achieved an impressive accuracy of 89.68% over 20 epochs, demonstrating the capability of the initial CNN architecture to accurately classify various types of skin lesions. However, Model 2, an improved version of Model 1 incorporating the augmented dataset, experienced a slight decrease in accuracy, reaching 62.05% over 20 epochs. This decline could be attributed because of the maximum dropout percentage used. On increasing number epochs upto 50 the accuracy is increased to 89.99%.

The Model 3, enriched with BatchNormalization layers and a rescaling layer, demonstrated the accuracy reaching 91.15% over 50 epochs. The inclusion of BatchNormalization layers contributed to stabilizing and accelerating the training process, resulting in improved model performance. The higher accuracy achieved by Model 2 underscored the importance of incorporating advanced techniques in the model architecture to enhance its ability to accurately classify diverse skin cancer types. Overall, the results highlighted the significance of data augmentation and the utilization of advanced model enhancements, emphasizing the potential of deep learning methodologies in accurate skin cancer classification. Major limitation observed is class imbalance problem. The dataset contains a significant difference in number of samples in every class. Due to this the model may struggle to perform well on the minority class.

4 Conclusion

In summary, the research paper highlights the importance of technological advancements in dermatological diagnosis by utilizing Machine Learning for remote detection of skin diseases. The overall accuracy observed is satisfactory for recognizing various skin conditions through non-invasive techniques like Convolutional Neural Networks and image processing using OpenCV. High accuracy significantly minimizes the risk of misdiagnosis and enables timely interventions, ultimately leading to improved patient care and outcomes. The major limitation observed is class imbalance problem in dataset. As a result, CNNs have become a cornerstone of modern dermatological research and practice, revolutionizing the field and paving the way for more effective and accessible healthcare solutions.

In future, first the focus will be on solving class imbalance problem and then integration of advanced techniques in multispectral imaging technology is planned to incorporate in skin disease classification. The system could capture images at various wavelengths, allowing for the analysis of different skin layers and components such as blood vessels, melanin, and collagen. This would enable a more comprehensive and detailed assessment of skin conditions, potentially enhancing the accuracy of disease identification and providing a deeper understanding of underlying skin pathologies. Furthermore, the incorporation of multispectral imaging could enable the system to detect subtle changes in the skin that might not be visible to the naked eye, thus facilitating the early detection of complex conditions like melanoma and other forms of skin cancer. For this work, only accuracy is used as performance measure in future some other measures also will considered for analysis.

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Comparative Analysis of Malaria Detection Using Predictive Algorithms

Tanay Thatte [1], Ujwal Khairnar [2] & Dr. A.R.Deshpande[3]

[1]Student; PICT Pune, (Computer Engineering), Pune, Maharashtra , India, tanaythatte17@gmail.com
[2]Student; PICT Pune, (Computer Engineering), Pune, Maharashtra, India, ujwalkhairnar5@gmail.com
[3]Associate Prof.; PICT Pune, (Computer Engineering), Pune, Maharashtra, India, arativb@gmail.com

Abstract:

Diseases, including Malaria, pose a significant threat to global public health especially in underprivileged communities. They do not affect physical health but also result in economic consequences. This research explores the potential of using data science and machine learning techniques to predict malaria outbreaks. By analyzing datasets containing factors like red blood cells count, white blood cells count , platelet count we developed predictive models to forecast malaria incidents. Models such as Random forest, Gradient boosting, and Support vector machines were tested, and their performance surpassed traditional methods. The findings emphasize the utility of these approaches in proactive public health planning, offering insights for effective resource allocation and intervention strategies.

Keywords: Malaria, Machine Learning, Random Forest, Gradient Boosting, Support Vector Machine.

1 Introduction

1.1 Background

A disease can be defined as any abnormal deviation from the normal functioning of an organism, generally associated with certain symptoms. Malaria is a disease caused by the parasite Plasmodium falciparum . It spread to humans through the bites of infected mosquitoes. Although in most cases Malaria is not very severe, however if proper treatment is not given it can prove to be fatal [10].

Malaria remains a major problem worldwide especially in tropical regions where the weather is humid. Despite many advances in prevention and treatment strategies, the complexity of malaria transmission continues to hinder effective disease control [14].

Machine learning which allows machines to learn and predict values based on past occurrences of a similar event is now being used to predict diseases by feeding past data [9]. This data can range from geographical factors of a particular region where disease occurrence is very high to patient data containing information about their blood tests or X-Ray scan or an MRI scan. By using Machine learning we can identify patterns associated with malaria transmission to enable more effective and targeted prevention interventions of the disease [11].

1.2 Literature Survey

In [1] application of various machine learning algorithms in predicting malaria outbreaks was observed, utilizing factors such as temperature, humidity, and population ratios. Among the algorithms tested, eXtreme Gradient Boosting (XGBoost), Artificial Neural Networks (ANN), and Random Forests demonstrated the highest predictive capabilities. Evaluation metrics such as accuracy, recall, precision, error rate, and Matthews Correlation Coefficient were used to

comprehensively assess the models. The research emphasizes the significance of data-driven insights to combat the spread of malaria.

In [2] a study was conducted in the Sundargarh district of Odisha, India, where the relationship between climate factors and malaria incidence was analyzed, using WEKA machine learning tools, they compared two techniques, Multi-Layer Perceptron (MLP) and J48, finding that J48 was more effective in predicting malaria with higher accuracy and lower error rates. The study highlighted the significance of seasonal temperature and humidity variations in influencing malaria outbreaks.

In [3] patient data was used to create machine learning models for malaria diagnosis. Race, disease type, gender, age, symptoms were among the patient variables that were identified using information from CDC reports and PubMed abstracts. The performance of six different learning machines—support vector machines, random forests, multilayer perceptrons, gradient boosting, AdaBoost, and CatBoost—is compared in this study. The outcomes show the potential of machine learning in this area by proving the efficiency of random forest models based on patient data for malaria prediction.

In [4] The objective of the study was to predict instances of malaria by making use of machine learning and clinical data. The researchers used various machine learning techniques along with clinical data to build models for predicting malaria. This research emphasizes on the significance of clinical data in predicting malaria by signifying the effectiveness of machine learning in detecting malaria at an early stage. These discoveries portrayed the connection between clinical treatment and disease management technologies, along with the accuracy of machine learning in forecasting malaria cases.

In [5] The 2020 paper authored by Mehmood, Mahmoud, and Adeel, and published in IEEE Access, delves into the realm of machine learning algorithms in the context of predicting malaria epidemics and conducting data analysis. The authors thoroughly explore various methodologies and strategies for forecasting malaria cases, while also scrutinizing pertinent data. Their research revolves around the utilization of machine learning techniques to enhance the precision of malaria prediction models through effective data processing and interpretation.

In [6] The Acta Tropica publication in 2018, authored by Karunamoorthi and Almadiy, provided a comprehensive analysis of contemporary techniques and obstacles in the field of malaria outbreak prediction modeling. The researchers delved into diverse methodologies and strategies employed for forecasting and averting malaria outbreaks, thereby illuminating the prevailing challenges and constraints.

In [7] the paper by Amara and Pradhan provides a systematic review of machine learning techniques applied to malaria risk modeling. This study assessed various machine learning methodologies, such as decision trees, random forests, support vector machines, and others, in the context of predicting and assessing the risk of malaria transmission.

2 Proposed Methods

2.1 Models Used

We have used Predictive Models such as Random Forest, Gradient Boosting and Support Vector Machine as these models are able to analyze large datasets, identify risk factors, and forecast the likelihood of disease occurrence. By integrating various clinical, genetic, and lifestyle data, these models can provide personalized risk assessments and early warnings [12, 13].

2.1.1 Random Forest

An ensemble learning approach called Random Forest bootstraps random subsets of the training data and takes random feature subsets into consideration at each split to create numerous decision trees [8]. Because the trees are more diverse due to this unpredictability, overfitting is less likely. Each tree "votes" for a class in classification tasks, and the final prediction is the majority class; in regression tasks, predictions are averaged. Combining several trees improves the model's robustness and accuracy, which makes Random Forests useful for a range of applications while reducing the drawbacks of single decision trees.

Step By Step Working :

1. **Data Bootstrapping:**
    - Randomly sample the training dataset with replacement, creating multiple bootstrap samples.
2. **Random Feature Selection:**
    - For each bootstrap sample, randomly select a subset of features at each split when building a decision tree.
3. **Decision Tree Building:**
    - Build a decision tree for each bootstrap sample using the selected features. Grow the tree until a certain criterion is met (e.g., maximum depth).
4. **Ensemble of Trees:**
    - Create an ensemble of decision trees by repeating steps 1-3, resulting in multiple diverse trees.
5. **Voting (Classification) or Averaging (Regression):**
    - For classification tasks, let each tree "vote" for a class, and the majority class becomes the final prediction. For regression tasks, average the predicted values from all trees.
6. **Aggregation:**
    - Combine the predictions of all trees to obtain the final prediction, providing a robust and accurate model.

$$F(X) = (\sum_{i=1}^{N} F_i\,(X))/(N) \quad \textbf{(1)}$$

Random Forest

X represents the input

$F_i(X)$ is the prediction of the i^{th} decision tree

N is the total number of decision trees in the Random Forest

2.1.2 Gradient Boosting

Gradient boosting is a powerful ensemble technique that corrects the errors of its predecessors by constructing a sequence of weak learners, typically decision trees, one by one. Gradient boosting involves fitting each new tree to its residuals, which are the differences between actual and expected values. The goal of each new tree in the gradient boosting iterative process is to minimize the errors caused by the collection of previous trees. Gradient boosting achieves high predictive precision and robustness by combining weak models in a weighted combination, where each tree improves the overall prediction. However, it tends to overfit if not regularized, and requires careful hyperparameter tuning. The efficiency and scalability of the gradient boosting algorithm have been greatly improved by well known implementations such as XGBoost or LightGBM.

Step By Step Working :

1. **Initialize the Model:**
    - Start with a simple model, usually a constant value (mean for regression problems or a class with the highest frequency for classification).
2. **Compute Residuals:**
    - Calculate the residuals by subtracting the predicted values from the actual target values.
3. **Build a Weak Learner:**
    - Train a weak learner (typically a shallow decision tree) on the residuals. The goal is to fit the model to the errors made by the current model.
4. **Compute the Learning Rate Multiplier:**
    - Introduce a learning rate (η), a small positive number less than 1, to control the step size in updating the model. This helps prevent overfitting and stabilize the learning process.
5. **Update the Model:**
    - Update the current model by adding the learning rate multiplied by the predictions of the weak learner to the previous model's predictions. This step minimizes the residuals.
6. **Repeat Steps 2-5:**
    - Repeat steps 2-5 until a specified number of weak learners are trained or until a certain criterion is met (e.g., achieving satisfactory performance).
7. **Final Prediction:**
    - The final prediction is the sum of the predictions from all the weak learners. For regression tasks, it's a continuous value, and for classification tasks, it's converted into probabilities or class labels.

$$F(X) = \sum_{i=1}^{N} \eta . f_i(X) \quad \textbf{(2)}$$

Gradient Boosting

F(X) is the final prediction

$f_i(X)$ represents the prediction of the i^{th} weak learner

η represents the learning rate, a small positive value that scaler the value of each learner

2.1.3 Support Vector Machine

Support vector machines (SVM) are supervised machine learning algorithms that attempt to find the best hyperplane in the space of data to distinguish different classes of data by maximizing the margin, which is the distance from the hyperplane to the nearest data point from each class, influenced by support vectors (the closest data points).SVM can work with non-linear separable data by transforming the feature space using a kernel function. The algorithm works well in high-dimensional space and can be used for classifying and regression tasks.SVM is versatile, but its performance is dependent on the kernel and parameter choices and it may not work well on large datasets.Despite these drawbacks, SVM is still widely used in various domains because of its robustness and its generalization capabilities.

Step By Step Working:

1. **Data Representation:**
    - Represent each data point as a feature vector in a multidimensional space.
2. **Initialization:**
    - Choose an initial hyperplane that separates the classes.
3. **Margin Maximization:**
    - Identify the support vectors (closest points to the hyperplane) and maximize the margin between classes.
4. **Optimization:**
    - Formulate an optimization problem to find the optimal hyperplane weights that maximize the margin while minimizing errors.
5. **Optimization Solving:**
    - Solve the optimization problem to obtain optimal weights and biases.
6. **Final Hyperplane:**
    - The optimal hyperplane is determined by the obtained weights, maximizing separation.
7. **Decision Function:**
    - Define a decision function based on weights and biases.

8. **Classification:**

- Classify new data points based on the sign of the decision function.

2.2 Dataset Used

For this research we have used hematological data collected from Ghana. Hematological Data tells us information about the blood samples collected.

2.2.1 Size

The dataset used has 2207 rows and 34 columns.

2.2.2 Parameters

The parameters present in our dataset are :

'SampleID', 'consent_given', 'location', 'Enrollment_Year', 'bednet',

'fever_symptom', 'temperature', 'Suspected_Organism',

'Suspected_infection', 'RDT', 'Blood_culture', 'Urine_culture',

'Taq_man_PCR', 'parasite_density', 'Microscopy', 'Laboratory_Results',

'Clinical_Diagnosis', 'wbc_count', 'rbc_count', 'hb_level',

'hematocrit', 'mean_cell_volume', 'mean_corp_hb', 'mean_cell_hb_conc',

'platelet_count', 'platelet_distr_width', 'mean_platelet_vl',

'neutrophils_percent', 'lymphocytes_percent', 'mixed_cells_percent',

'neutrophils_count', 'lymphocytes_count', 'mixed_cells_count',

'RBC_dist_width_Percent'

The output will be given by the Clinical Diagnosis column. As input to our models we will use the parameters :

'wbc_count', 'rbc_count', 'hb_level',

'hematocrit', 'mean_cell_volume', 'mean_corp_hb', 'mean_cell_hb_conc',

'platelet_count', 'platelet_distr_width', 'mean_platelet_vl',

'neutrophils_percent', 'lymphocytes_percent', 'mixed_cells_percent',

'neutrophils_count', 'lymphocytes_count', 'mixed_cells_count',

'RBC_dist_width_Percent'

All these parameters can be directly obtained from a blood sample [15].

2.3 Preprocessing Techniques

From our dataset our output value will be 'Clinical Diagnosis'. We will consider parameters such as white blood cells count, red blood cells count, hemoglobin level, mean cell volume and all the values which can be derived from a blood test. We will use these parameters to train our model. For better accuracy we will convert our data into an integer value and scale it between 0 and 1. We will then divide our dataset into training dataset and testing dataset in a ratio of 80:20.

3. Results & Discussion

We have passed our training dataset into our Models which are Random Forest, Gradient Boosting and Support Vector Machine. We then test the accuracy of our model by comparing it with our testing dataset. There are 3 possible outputs which are :

- Severe Malaria – When malaria is present and very severe such that it can lead to death of the patient
- Uncomplicated Malaria – When malaria is present but not severe
- Non-Malaria Infection – When malaria is not present in the patient

3.1 Random Forest

Table 1 Random Forest Results

Type	Precision	Recall	F1 Score
Severe Malaria	0.94	0.97	0.96
Uncomplicated Malaria	0.81	0.66	0.73
Non-Malaria Infection	0.81	0.90	0.86

On testing with Random Forest Model we get the above results. The overall Accuracy of Random Forest model is 0.84.

3.2 Gradient Boosting

Table 2 Gradient Boosting Results

Type	Precision	Recall	F1 Score
Severe Malaria	0.96	0.95	0.95
Uncomplicated Malaria	0.73	0.66	0.69
Non-Malaria Infection	0.80	0.85	0.83

On testing with Gradient Boosting Model we get the above results. The overall Accuracy of Gradient Boosting model is 0.83.

3.3 Support Vector Machine

Table 3 Support Vector Results

Type	Precision	Recall	F1 Score
Severe Malaria	0.94	0.95	0.94
Uncomplicated Malaria	0.79	0.66	0.71
Non-Malaria Infection	0.80	0.89	0.85

On testing with Support Vector Machine Model we get the above results. The overall accuracy of Support Vector Machine Model is 0.83.

3.4 Testing with variation of Training and Testing Datasets

We have also tested how the accuracy of a model changes when we change the ratio of training size : testing datasize. The results are as follows :

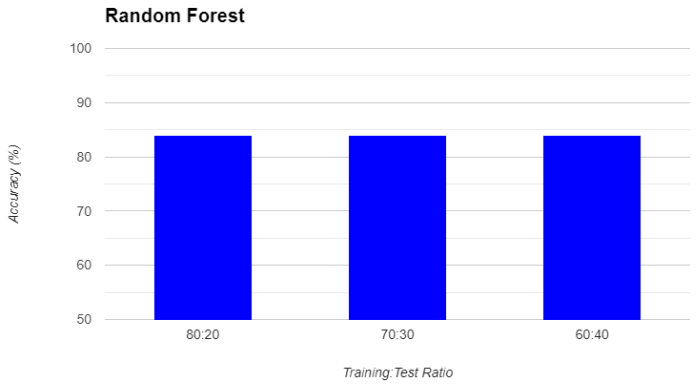

Fig 1 Random Forest Testing

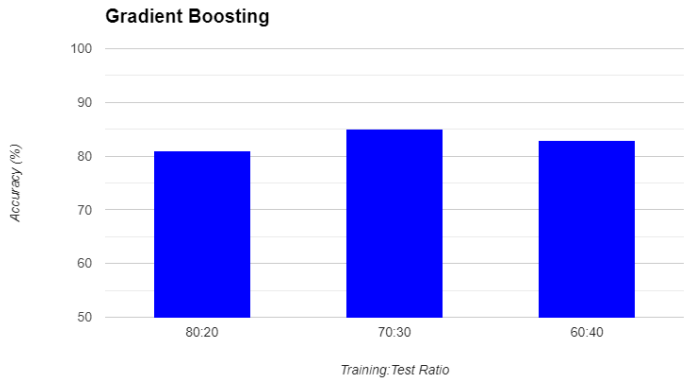

Fig 2 Gradient Boosting Testing

Even after altering the training : testing ratios Random Forest is the most efficient model. For all 3 models we can see that we get the highest accuracy when the Training : Testing ratio is 70 : 30.

3.5 Discussion

We have tested the accuracy with same training and testing dataset for all 3 of our models. On comparing from Table 1, Table 2 and Table 3 we can see that Random Forest model gives the highest accuracy of 84% compared to Gradient Boosting's 81% and Support Vector Machine's 83%.

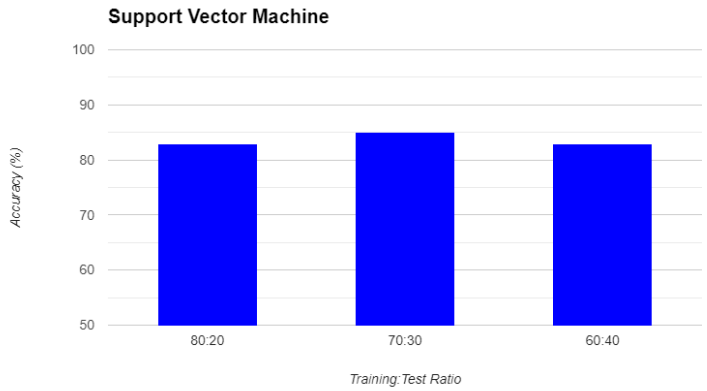

Fig 3 Support Vector Machine Testing

We also decided to change the training: testing ratios to see the variation of accuracy in the models. On changing the ratio to 70: 30 we can observe from Fig 1, Fig 2 and Fig 3 that accuracy of Random Forest remains constant at 84%, whereas accuracy of Gradient Boosting and Support Vector Machine increase to 85%. When the ratio was made to 60: 40 we observed that the accuracy of Random Forest remained constant at 84%, whereas accuracy of both Gradient Boosting and Support Vector Machine dropped to 83%.

We can say that Random Forest Model provides the most accurate predictions and it's accuracy does not vary on changing the training: testing ratios.

4 Conclusion

In conclusion our research demonstrates the use of machine learning in predicting malaria outbreaks. We have tried to predict malaria by passing data related to patient's blood.

For a Machine Learning Model an accuracy of 84% might be good, however when dealing with a critical issue such as disease prediction we should always aim at improving our model for a better accuracy as it can help in saving lives. In future we can try on expanding datasets and using more diverse datasets.

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SEMANTIC WEB AND ONTOLOGIES

Adwait Desai [1] Mr. Sandip Warhade [2]

[1]Student; Pune Institute of Computer Technology, (department-IT), Pune, Maharashtra, India, adwait393@gmail.com
[2]Assistant Prof.; Pune Institute of Computer Technology (department-IT), Pune, Maharashtra, India, srwarhade@pict.edu

Abstract:

The Semantic Web, the cornerstone of web 3.0, relies on ontologies to manage data heterogeneity and enable automated information repurposing and analysis. However, choosing an appropriate ontology in line with user requirements remains a challenging problem due to the time and effort required, the lack of context awareness, and the computational complexity. This work proposes an ontology recommendation system that combines text classification with unsupervised learning techniques to overcome these challenges. The proposed study offers a number of benefits, including minimal computational complexity, effective ontology organization, reduced time and effort spent selecting appropriate ontologies, and adaptability to a range of domains and online ontology libraries. At last, I have provided the case study for better understanding how a complete semantic web will work.

Keywords: recommendation system, data heterogeneity, unsupervised learning, ontologies, text categorization, Semantic Web

1.Introduction

The topic of this seminar proposes an ontology recommendation system that combines text classification and unsupervised learning techniques to suggest the optimal ontology based on user requirements, grouping ontologies according to comments from domain experts. The article also includes a description of the software requirements for the proposed framework. It also discusses a variety of approaches and various Machine Learning Algorithms, such as K-Means Hierarchical clustering. Basically, I have compared the three methods to understand which one is the most suitable for semantic web and ontologies.

Table 1.1 Comparison between Semantic and Traditional Web

Characteristic	Semantic Web	Traditional Web
Data Representation	RDF, structured data	HTML documents, unstructured
Data Meaning	Machine-readable, annotated data	Primarily human-readable text
Data Interconnection	Strong interconnection through RDF triples and linked data	Limited interconnectivity between documents
Search and Discovery	Semantic search engines, context-aware	Search engines based on keyword matching
Human Interpretation	Automated processing, reasoning	Relies on human interpretation and browsing
Data Integration	Automatic integration through ontologies and RDF graphs	Manual integration and data transformation
Data Inference	Supports inference, reasoning	Lacks inference capabilities
Scalability	Scales well due to structured data	Becomes challenging with unstructured data growth
Data Consistency	Promotes data consistency and integration	Inconsistent and prone to data silos
Domain Knowledge	Encourages domain-specific ontologies	Lacks formalized domain knowledge
Semantic Interoperability	Enhanced semantic interoperability through shared ontologies	Limited semantic interoperability
Data Trustworthiness	Promotes data trustworthiness and provenance	Data source reliability can be challenging to determine
Real-World Applications	Used in knowledge graphs, data integration, intelligent agents, etc.	Primarily used for information sharing and e-commerce

2.Literature Survey

Table 2.1 Literature Survey

Year	Author	Paper Name	Description
2020	Mohsin Raza,Mansour Ahmed,Asad Habib	Exploting Ontology using text categorization	Provides overview of Ontology Recommendation and text categorization approach, compares different ML algorithms to find out the best use of each.
2023	Weijun Tan	Overlooked video classification inWeakly supervised anomaly detection	Basically this paper is about deep learning approaches which involve video classification.
2023	Yijin Lin,Zhipeng Gao,Hongyang Du,Dusit Niyato	A unified Blockchain-Semantic Framework for Wireless Edge Intelligence Enabled Web 3.0	Provides a framework which integrates blockchain technology, semantic web and wireless edge computing address the challenges of Web 3.0
2023	Xu Zhang, Tong Li, Zhan Ma	AI and Blockchain Empowered Metaverse for Web 3.0: Vision, Architecture and Future Directions	This paper provides the architecture for AIB-Metaverse , which brings in the picture together usage of AI and Blockchain.

3 .Proposed Methods

2.1.1 Proposed Framework

The proposed design calls for the establishment of an ontology repository, the gathering of user needs, and the construction of an unsupervised learning and text classification-based recommendation system. Based on user needs, the framework offers the most relevant ontology by grouping similar ontologies into clusters. By proposing the one most suitable ontology, this framework seeks to get over the drawbacks of giving users a plethora of results. To save developers time and effort, it uses unsupervised learners and text classification to suggest the best ontology to the user.

By supporting data providers, information engineers, and ontology designers—both fresh and experienced—identify the right ontology and cut down on the time and effort needed to do so, the suggested approach may be used to promote ontologies. In order to analyze how well the ontology recommendation engine organizes ontologies, predicts the appropriate ontology group, and recommends ontologies based on user needs, the framework also has a performance assessment model .

Four stages constitute the building process of the framework's functionality: ontology crawling, pre-processing tasks, unsupervised learning, and ontology suggestion. In ontology crawling, ontology words and text are

obtained, pre-processing operations are carried out over user needs and ontology data, related ontologies are grouped using unsupervised learning, and an ontology is recommended for the specified user demand .

A). Ontology Recognition:

The methodical process of collecting ontologies from many sources, including literature, internet databases, and domain-specific databases, is known as "ontology recognition." This entails locating, obtaining, and compiling ontologies relatable to certain domains or topic areas. Establishing and upholding ontology repositories requires ontology crawling, which makes sure that a wide variety of ontologies are available for additional examination and advice. Concerning the topic under discussion, ontology recognition plays a pivotal role in enriching the ontology collection with a variety of relevant and varied ontologies from various domains. This allows the framework to suggest the most suitable ontology to users depending on their specific requirements.

B). Pre-Processing

Preprocessing includes a series of procedures to get the data ready for further examination. I've covered word indexing, lemmatization, and stop-word elimination as three methods for pre-processing here. To decrease data sparsity and feature set size, stop-word removal removes words like propositions and pronouns that convey no meaning or information. Lemmatization reduces word duplication caused by capital or lowercase variations by grouping inflected variants of a word into a single item.

Stop-word Removal: Removing words that give no relevance to the data which may be adjectives.
Lemmatization: Uniform representation of words to remove data duplication.
Word Indexing: Texts are converted to numeric data to make data more analysable.

C) Clustering

Cluster is collection of related object, example is how we say cluster of stars. Clustering includes the groups of data formed for their analysis and to drive some conclusions or make predictions. It is a prediction based business intelligence method.

There are several clustering methods:
1)K-means
2)Hierarchical

1) K-means: Heuristic method, where each cluster is represented by center of clusters.
   K stands for umber of clusters.
   Algorithm:
   - Selection initial centroid at random.
   - Assign each object to cluster with nearest centroid.
   - Compute each centroid as the mean of objects assigned to it.
   - Repeat the steps until no change.

2) Hierarchical: Uses distance matrix as clustering criteria. This method does not require the number of clusters K as an input, but needs termination condition. Represented by a Dendogram . Logic used here is linkage.

Table 3.1.C- Comparison Of various Hierarchical Clustering approaches

Agglomerative Clustering	Divisive Clustering
Follows a top-down approach	Follows bottom up approach
Clustering occurs group by group as initially each item is in its own clusters.	First a large cluster is formed and based on similarities small clusters are made.

Some methods that are used to increase the accuracy of text categorization are as follows:

1. Binary: This basic weighting technique assigns a word a weight of 1 if it appears in the document and 0 otherwise. This technique is employed to indicate if a phrase is in a document or not .

2. Term Frequency-Inverse Document Frequency (TFIDF): This numerical metric illustrates the importance of a term to a document in a collection or corpus. In order to account for terms that appear more frequently overall, it considers both the frequency of a term in a document and the total number of documents in the corpus that contain the phrase.

3. Entropy: -Entropy is comparable to a randomness or surprise metric. It helps us comprehend how much a word may disclose about a particular document in the context of text classification.

4. Term Frequency Collection (TFC): TFC is a sophisticated variant of TFIDF, a text analysis tool. Unlike TFIDF, TFC examines the whole length of the document in addition to the frequency of terms appearing in it.

5. Length Term Collection: LTC is a clever method of managing the frequency with which words appear in a manuscript. To ensure that words which appear frequently enough are noticed and that ones that appear infrequently enough are not overemphasized, it employs a method involving logarithms.

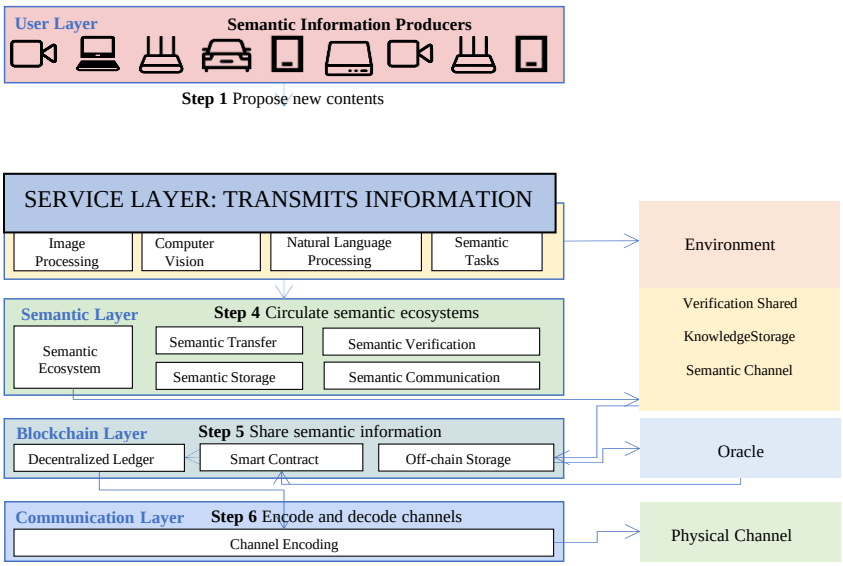

Figure 1: Probable Semantic Web Architecture ([1]Unified Blockchain-Semantic Framework)

4. Results and Discussions

Ontology need arises in many cases such as University databases. They can be used while choosing an engineering course as well.
Example: If you are confused about choosing a course, the counsellor asks you to name the subjects you are interested in. You say mathematics, physics, c-programming and Java. With the answers that you provided to the counsellor, he relates all different subjects and finds that the most suitable course for you is Computer Science course.
I have also explained a case study at the end, stating what makes the website completely semantic.

4.1.1 Dataset Discussion

I have taken the dataset from my reference paper [2] . The dataset in the paper is collected manually which consists of 30 user requirements. The evaluation is done, and effectiveness of the method is found out.
Why User Needs Are Important: - Assume You Have Queries Imagine that you are a person with a ton of queries, such as the desire to learn computer science ideas, discover the ideal recipe, or research academic subjects. Every one of these inquiries resembles a distinct demand you may have.

The Large Electronic Library: - Where Solutions Are Stored: Imagine a vast digital library with shelves crammed with knowledge on anything from computer science to academics, as well as recipes for your favorite foods and drinks.

Your Individual Assistant - The Structure: -What Functions It Has: Let's say you have a very intelligent digital companion that we'll refer to as the Framework. This acquaintance is proficient at using the online library. When you explain to your friend what it is you're interested in learning about (your user needs), they say, "Okay, let me locate the ideal section."

An ontology may be necessary in the academic area in order to administer university information systems, according to user needs. Criteria for separating and organizing data on classes, instructors, students, investigations, and academic departments may fall under this category. The ontology could be needed by users to make things like course scheduling, student enrolment, faculty administration, and research cooperation easier. Furthermore, in order to facilitate the effective integration and retrieval of data from diverse university databases and systems, the ontology might also need to record the relationships and characteristics of academic entities.

User needs in the science of computing domain could include the necessity for an ontology to describe ideas relevant to computer science, such as problem monitoring, methods for developing software, and software design patterns. To assist activities like programming, bug monitoring, and software architecture design, users might need the ontology. In order to facilitate the structuring and recovery of information pertaining to computer science ideas, the ontology might require to include the connections and qualities associated with software sections, design conventions, and development processes.

4.1.2 Comparison for different approaches that can be used to make the web Semantic:

Table 4.1.2.1 Comparing different algorithms

Characteristic	K-Means	K-Medoids / Content Recommendation
Algorithm Type	Clustering	Clustering / Recommendation
Purpose	Data clustering and segmentation	Data clustering and segmentation / Suggesting relevant content to users
Semantic Web Integration	Limited	Limited / Integral for personalized content recommendations
Data Types	Numeric data	Numeric data / Structured and unstructured data
Semantic Data Usage	Minimal	Minimal / Relies on semantic data for user preferences and context
Ontology Usage	Rarely involves ontologies	Rarely involves ontologies / May use domain-specific ontologies
User Engagement	Typically not focused on user interaction	Typically not focused on user interaction / Designed for user engagement
Real-World Applications	Data segmentation, customer segmentation	Data segmentation, outlier detection / Recommending products, articles, videos, etc.
Challenges	Limited use of semantic data	Limited use of semantic data / Handling semantic data and user preferences

4.1.3 Diagrams

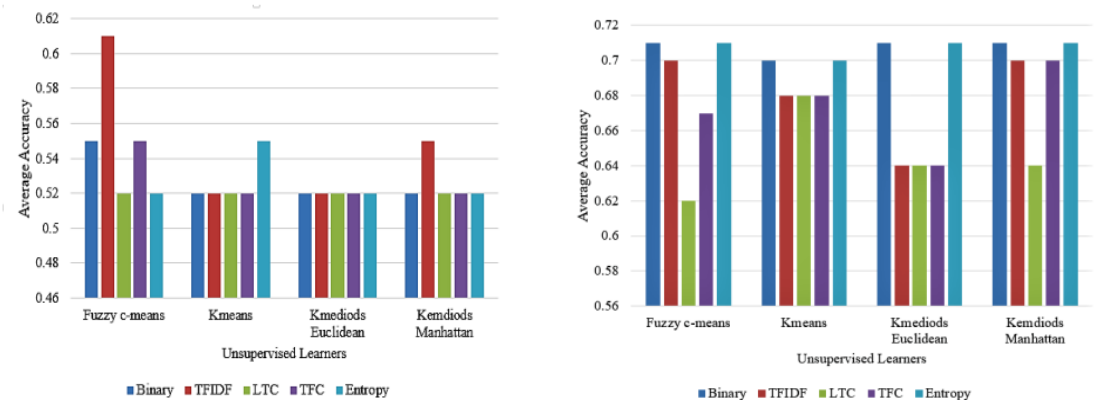

Figure 4.2.2 a) Academic domain b)Computer Domain ([2]Exploiting Ontologies)

	Fuzzy-c	K-means	Kmedoids	Kmedoids Manhattan
Academics	0.65	0.43	0.61	0.81
Computer	0.78	0.66	0.69	0.60

4.1.4 Conclusions

Inference from the Table:

Even though each algorithm has its own advantages and disadvantages, we cannot say which one is the best suitable algorithm to use in semantic web. The approach of using different algorithms can be determined with respect to the size of dataset provided or obtained. As clustering algorithms come in the category of prediction based algorithms, we cannot use evaluation metrices such as accuracy score as we use in description based algorithms (Eg:Naïve Bayes).

Now considering the example of dataset which is related to semantic web, where each data point represents a research paper. Research paper also includes metadata such as author information , abstract , keywords etc.
In this case if the dataset is too large, K-means will be used due to its computational complexity.
If the dataset contains topics, various subtopics which form a hierarchy then Hierarchical clustering will be used.

5.Acknowledgement

I would like to thank my institution Pune Institute of Computer Technology for providing such an opportunity and all the associated faculties who guided me to write my first ever paper.

6.References:

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Smart Chatbot with Document Retrieval and Extractive Question Answering

Mr. Virendra Bagade[1] Dr. S. P. Godse[2]

[1] Student, Computer Engineering, VIIT Research Center, Pune, Maharashtra, India, virendrabagade1104@gmail.com
[2] Assistant Prof; Computer Engineering, VIIT Research Center, Pune, Maharashtra, India, sachin.gds@gmail.com

Abstract:
Support engineers on various projects deal with many problems while carrying out their daily work. When they face an issue in a project, they have to read a large amount of relevant documentation to figure out what should be the fix to the issue at hand. They often have to read many of the documents that can be too technical and time consuming to read through every section. In the age of artificial intelligence and automation, we can leverage natural language processing methods to ease this process.

Index Terms - Chabot, information retrieval, natural language processing, neural search, document.

Introduction:
To solve this problem faced by support engineers, we propose an interactive smart dialogue system that can converse with a support engineer and provide them with the appropriate responses for their queries. To make this dialogue system more natural, we make it so that the Chabot can not only provide info on the required topic but also talk naturally with the support engineer interacting with it. This means that the Chabot would reply promptly to queries such as "How are you?", "What is your name", "Bye" with replies such as "I am great! How are you?", "I am the support Chabot for your help." and "Have a good day!" respectively. This would make it much easier for the engineer to interact with the software. Along with the natural responses to questions we ask in daily life, we train our Chabot to detect queries that need their answers fetched from documentation. Once we detect a query such as "What is Ubuntu?" we then pass this question onto a neural search module that uses Elastic Search to find out which document has the highest probability of containing the answer. We achieve this by indexing all the documents with Elastic Search and BM25. We use the haystack framework to implement this search module. We first integrate the Chabot and the neural search module together such that if we detect the query, we can send the query to our neural search module to find out what document will contain our answer. To achieve the final step, that is to fetch the answer from the document and present it to the user. We do this with a RoBERTA model that is fine-tuned on a question answering dataset SQuAD 2.0. Extractive question answering works in a way such that we need to pass the question as well as the document as context and get the answer as an output. This step can take a significant amount of time depending on the size of the model and the availability of a Graphics Processing Unit for extractive question answering. Once we fetch the answer or the top 3 answers, we integrate this extractive question answering module with our Chabot that after sending the query to neural search is waiting for a response API. Once we receive the answer, we present it to the user in the Chabot user interface.

II. RELATED WORK

1] L. Yang, H. Zamani, Y. Zhang, J. Guo, and W. B. Croft used neural matching models and per- formed question retrieval and next question prediction on the Quora questions dataset and Ubuntu chat logs. Information Retrieval methods like BM25, TRLM and LSTM-CNN-Match are used. Out of these, the LSTM-CNN-Match gives the best results for question retrieval as well as next question prediction.

2]W. Wu, G. Liu, H. Ye, C. Zhang, T. Wu, D. Xiao, W. Lin, and X. Zhu,"EENMF have come up with a neural matching framework for ecommerce ads. The authors have proposed a two-stage deep matching framework for vector-based advertisement retrievals and pre-ranking these ads by using neural networks.

3] Contains a full-fledged literature regarding neural methods for information retrieval. B. Mitra and N. Craswell have shed light on the origins of information retrieval, text representations, term embeddings, deep neural networks and deep neural models for Information Retrieval.

4] J. Guo, Y. Fan, X. Ji, and X. Cheng, "Matchzoo suggested a system for neural matching tasks, through a user interface where researchers and users can apply a host of techniques like Data Preparation pipeline, Automatic ML, Model Construction, Model Designing and Model practicing.

5] T. Bunk, D. Varshneya, V. Vlasov, and A. Nichol have proposed a transformer-based architecture for intent classification and entity recognition, which is better than BERT and also faster to train.

6] In this paper T. Bocklisch, J. Faulkner, N. Pawlowski, and A. Nichol proposed the original Rasa chat-bot framework, which contains the Rasa NLU and various NLP techniques and ML libraries.

7], a new model called Hybrid Co-Attention network is proposed by J. Rao, L. Liu, Y. Tay, W. Yang, P. Shi, and J. Lin. A study related to semantic and relevance matching is also carried out.
Graph Neural Networks are leveraged by X. Ling, L. Wu, S. Wang, G. Pan, T. Ma, F. Xu, A. X. Liu, C.Wu, and S. Ji

8], to carry out semantic code retrieval. The model called DGMS was tested on two public code retrieval datasets of Java and Python language.
A new algorithm which implements semantic matching called S-Match was proposed by F. Giunchiglia, P. Shvaiko, and M. Yatskevich

9]. Mapping between nodes of two semantically-related graphs is done in this method.
Y. Fan, J. Guo, X. Ma, R. Zhang, Y. Lan, and X. Cheng present a comprehensive study on relevance modeling in

10] and put forth ideas related to comparing differences with respect to the Natural Language Understanding and how it can be improved.

11]Z. Zeng, D. Ma, H. Yang, Z. Gou, and J. Shen propose a domain-independent tool for automatically doing intent-slot induction. This tool resulted in a better performance in State-Of-The-Art results by 76
An all-inclusive model for knowledge relevance, topical relatedness and semantic similarity is proposed by X. Li, J. Mao, W. Ma, Y. Liu, M. Zhang, S. Ma, Z. Wang, and X. He in 12] which helps estimate the relatedness between query and document.

III. METHODOLOGY

The proposed work consists of three major modules namely

1) Chatbot module
2) Search Module
3) Extractive Question Answering

A. Chatbot Module

The function of chatbot is to make use of an intent classifier to classify messages given by the users into various predefined intents. It has to then decide the response to be given based on these intents according to the rules set by the programmer. e.g.) User : "Hello" this message will be classified as "greet" intent and the program/bot will output a response as "Hi, how may I help you". Similarly, if the user inputs a message saying "Who are you?" or "Are you a bot?" The intent classifier will classify it as "bot challenge intent" and will output a predetermined response as set by the programmer.

If the intent is not one of the predefined ones then it will be classified as a query and will be sent to the neural search module as a search string. The neural search module will then look for the query in documents present on the intranet and will return the search results. The intents used are listed as follows:

1) Knowledge question: This intent is used for questions asked by the user which require access to data. e.g. What is the capital of France?

2) greet : This intent is used for simple greet dialogues. e.g. Hi, Hello, good evening, etc

3) goodbye: The goodbye intent is used for exit dialogues. e.g. Bye, see you later etc.

4) affirm : This intent is used for affirmative responses. e.g. yes, indeed, etc.

5) bot challenge: This intent is used for questions like "who are you?" which asks for the identity of the chatbot. e.g. Who are you?Are you human?

6) Nlu fallback: This intent is used when the response cannot be classified into any of the above intents.

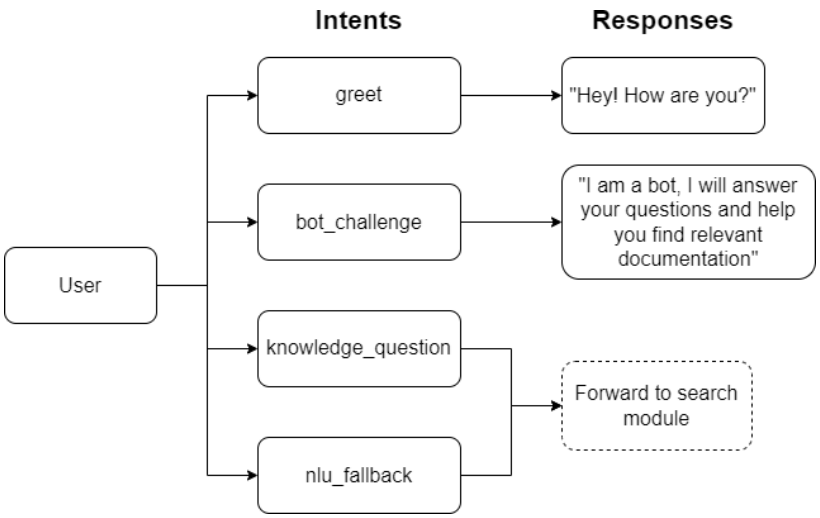


Fig. 1. Chatbot flow Diagram

B. Search Module

The search module is used to fetch the documents which are most relevant to the search query. For this we experimented with various algorithms such as Levenshtein Distance and BM25. The Levenshtein distance is a string metric for measuring the difference between two sequences. Informally, the Levenshtein distance between two words

is the minimum number of single-character edits (i.e. insertions, deletions or substitutions) required to change one word into the other.

$$lev_{a,b}(i,j) = \begin{cases} \max(i,j) & if\ \min(i,j) = 0 \\ & otherwise \\ min \begin{cases} lev_{a,b}(i-1,j) + 1 \\ lev_{a,b}(i,j-1) + 1 \\ lev_{a,b}(i-1,j-1) + 1 \end{cases} \end{cases} \quad .. \textit{ Equation-01}$$

Fig 2. Levenshtein Distance Formula equation-01

The BM25 algorithm is a vector-based string searching method. It's the successor to TF-IDF and is the result of optimizing TF-IDF primarily to normalize results based on document length. It saturates tf after a set number of occurrences of the given term in the document and it normalizes by document length so that short documents are favored over long documents if they have the same amount of word overlap with the query.

These are sparse methods, that is they operate by looking for shared keywords between the document and query. We use Elasticsearch to implement the BM25 algorithm and for indexing the documents.

$$BM25(D,q) = \frac{f(q,D)*(k+1)}{f(t,D)+k*(1-b+b*\frac{D}{d_{eq}})} * \log\left(\frac{N-N(q)+0.5}{N(q)+0.5}+1\right) .. \textit{ Equation-02}$$

Fig. 3. BM-25 distance formula

Using elasticsearch helps us to achieve fast results as it's written in Java and use its features such as distributed nature, ability to access using a REST api and to later deploy it as a hosted or managed service.

C. Extractive question answering module

The function of this module is to extract the answers of the given question using the context fed to it. The context is retrieved by the search module. For this we use the roberta- base QA model trained on the SQuAD 2.0 dataset. The model was trained on the SQUAD data-set that is a reading comprehension data-set, consisting of questions posed by crowdworkers on a set of Wikipedia articles. Here, we are able to extract the answer given the question and the context from which to extract the answer. The documents retrieved using the retriever module act as the context to the Question Answering model.

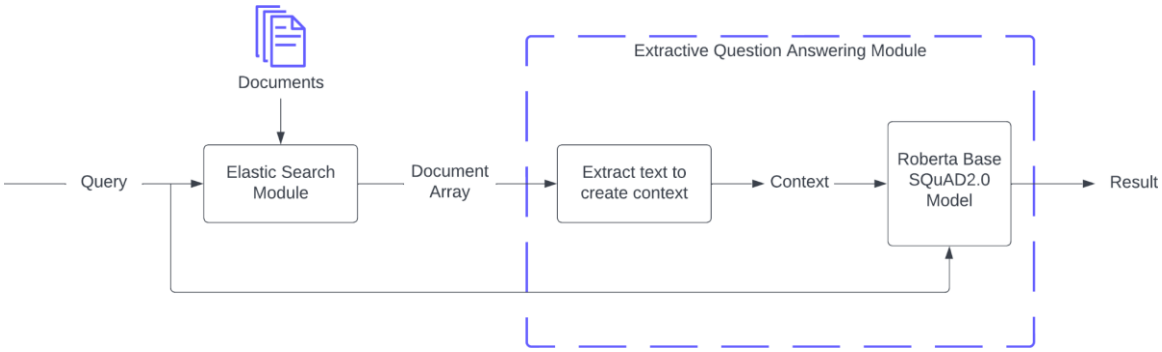


Fig. 4. Extractive Question Answering

D. Knowledge Graph construction module

Knowledge Graphs were first proposed by the Google Search team. Data is structured and represented in a graphical format. Knowledge Graphs, as the name suggests is a graph which contains entities as nodes and actions as edges. They help in linking and unifying the data. These are mostly directed graphs, with nodes and links containing specific domain-related information. This data structure represents a network of entities, and the relationships that exist amongst them.

For a collection of text documents, we have first transformed the text documents into csv files. Each sentence in the document is stored as an individual data entry in the csv file or in the form of a list. We construct the knowledge graph for a document by first splitting the sentence into its subject, object and predicate. The subject here refers to who the information is about, the object refers to what and the predicate is generally the verb, which tells the connection between the subject and object. The knowledge graph is thus represented as having subject and object as the nodes, with the edges going from subject to object, and the edge contains the verb or action extracted from the sentence. Representing information in the form of Knowledge Graph will help in retrieval and also produce relevant results accord- ing to the query passed by the users.

E. Document Similarity Module

Document similarity module facilitates comparing different documents with help of a common mathematical metric. In this module the text is encoded into a 512 dimension vector, irrespective of the size of the document. In order to compare two documents each document is encoded to a 512 dimension vector. Cosine distance between these vectors is then calculated. The cosine similarity is then calculated from this distance.

$$cosine\ distance = 1 - cosine\ similarity.. \quad ..Equation\text{-}03$$

$$cosine\ similarity = \cos\theta = \frac{\sum_{i=1}^{n} A_i B_i}{\sqrt{\sum_{i=1}^{n} A_i^2}\sqrt{\sum_{i=1}^{n} B_i^2}}$$

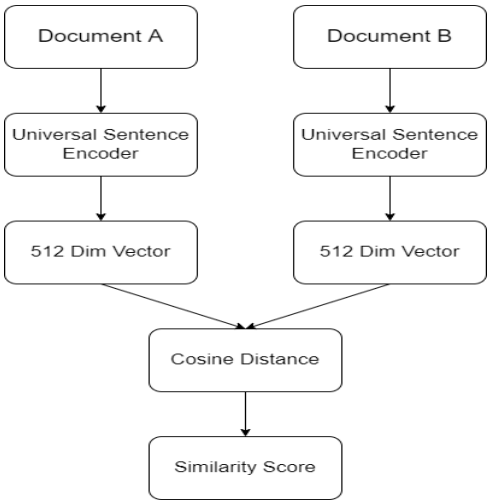


Fig 5. Document Similarity

F. Table Question Answering Module

Given a query, we will search a large number of indexed tables and find the respective record or group of records that can answer the query. Haystack provides models and APIs to fetch tables and then use various models such as TAPAS to encode tables for further retrieval. We also use a tri-encoder model that has separate encoders for table, text and query. The models are based upon BERT architecture. The indexing will require a GPU to speed up the process significantly. For this we use the bert-small-mm-retrieval-question-encoder model.

IV. ALGORITHMS OR MODELS USED

1) RoBERTa:

RoBERTa is a pretraining approach to BERT that fully leverages the capabilities of BERT with the right hyperparameters and training size. They use the same model and achieve state-of-the-art accuracy on various tasks. The model achieves these accuracies on GLUE,RACE and SQuAD datasets. For pretraining, they use tasks like Masked Language Modelling and Next Sentence Prediction.

Proposed Model Implementation Pseudo Code:

```
procedure PreprocessData [P]:
        initialize tokens[]
        for each para in paragraphs:
                para = removeNonAscii(para)
                para = removeFormat(para)
                para = removeStopWord(para)
                tokens[i] = tokenize(para)
        return tokens
end procedure
procedure AnswerQuestion[P]:
        initialize tokens[] = use procedure ProcessData[p]
        initialize maskedTokens[] = applyMask(tokens[])
        initialize start_logits, end_logits = predictLogits(maskedTokens[])
        initialize normTokens = applyNorm(start_logits, end_logits)
```

```
        return deTokenize(normTokens)
end procedure
```

2) TAPAS:

TAPAS stands for Table Parsing. This model is trained to understand tables and answer questions based on the data we have in the form of tables. This model overcomes the need to generate logical forms. It uses weak supervision rather than a fully supervised approach. It predicts a bunch of cells as the answer and then optionally applies an aggregation function that can give answers based on more than one row. TAPAS adds a table as an input to the core model of BERT and is then trained fully. It performs on par with WIKISQL and WIKITQ datasets, with a very simple approach. It also surpasses the state- of-the-art when using transfer learning from one dataset to another.

A. Transformers

Transformers were developed to solve the problem of sequence transduction, or neural machine translation. That means any task that transforms an input sequence to an output sequence. This includes things like speech recognition and text-to-speech conversion. Prior to transformers, most state- of-the-art NLP systems depended on gated RNNs with extra attention mechanisms, such as LSTM and gated recurrent units (GRUs). Transformers are created utilizing these attention technologies without the use of an RNN structure, demonstrat- ing that attention mechanisms can match the performance of RNNs with attention. Because token computations are depen- dent on the results of prior token computations, parallelization on present deep learning hardware is difficult. As a result, RNN training may become inefficient. Attention methods were used to solve these issues. Attention mechanisms allow a model to draw from any previous state in the sequence. The attention layer can access all previous states and weigh them according to a learned measure of relevancy, providing relevant information about far-away tokens.

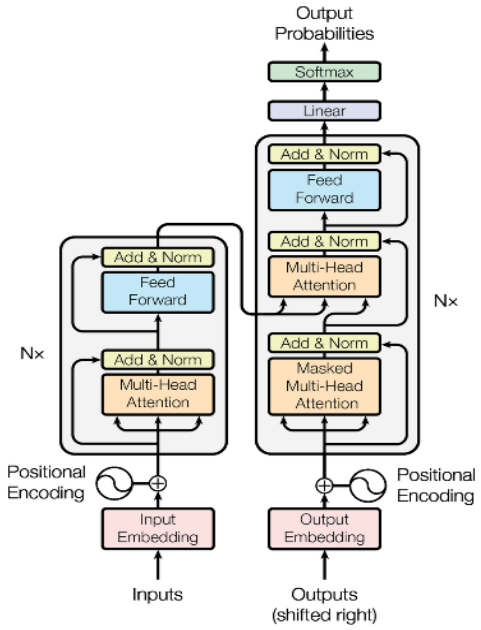


Fig 6. Transformer Model Architecture

B. The BM-25 Algorithm

Okapi BM25 (BM stands for best matching) is a ranking formula used by search engines to estimate the relevance of content to a certain search query. The BM25 retrieval function scores a set of documents based on the query phrases that exist in each document, independent of their closeness within the text.

Given a query Q, containing keywords *q1, ..., qn*, the BM25 score of a document D is:

$$score(D,Q) = \sum_{i=i}^{n} IDF(q_i) * \frac{f(q_i,\ D) * (k_i + 1)}{f(q_i,\ D) +\ k_1 * (1 - b + b * \frac{|D|}{avgdl})}$$

..Equation-04

Where,

- *f(qi , D)* is qi's term frequency in the document D.
- *|D|* is the length of the document D in words.
- avgdl is the average document length in the text collection from which documents are drawn.
- *k1* and *b* are free parameters, usually chosen, in absence of an advanced optimization, as $k1 \in [1.2, 2.0]$ and *b = 0.75*.
- *IDF(qi)* is the *IDF (inverse document frequency)* weight of the query term *qi*.

IDF(qi) is usually computed as:

$$IDF(q_i) = \ln\left(\frac{N - N(q) + 0.5}{N(q) + 0.5} + 1\right)$$

Equation-05

Where,

- N is the total number of documents in the collection.
- *n(qi)* is the number of documents containing *qi*.

The formula's IDF component counts how many times a term appears in all of the documents and "penalizes' ' terms that appear frequently.

Because the multiplier for inquiries containing these more uncommon terms is higher, they contribute more to the final score. In practically every English document, the word "the" will appear. As a result, when a user searches for "the elephant," "elephant" is likely to be more essential — and we want it to contribute more to the score.

The score for the document lowers as terms not matching the query in the document increase. If a 400-page document only mentions a word once, It's less likely to play a role in it than a brief sentence that mentions it once.

The effectiveness of BM25 is the major feature that makes it popular. It performs very well in many ad-hoc retrieval tasks.BM25 is the current state-of-the-art TF-IDF-like retrieval model. However, there are some approaches for normalizing document length and satisfying the term frequency's concavity criterion (e.g., considering the logarithmic TF, instead of the raw TF).

Based on these heuristic techniques, BM25 often achieves better performance compared to TF-IDF.

C. The Levenshtein Algorithm

Levenshtein distance is a string metric for measuring the difference between two sequences. Informally, the Levenshtein distance between two words is the minimum number of single- character edits (insertions, deletions or substitutions) required to change one word into the other.

$$lev_{a,b}(i,j) = \begin{cases} |a| & if\ |b| = 0 \\ |b| & if\ |a| = 0 \\ lev\big(tail(a), tail(b)\big) & if\ a[0] = b[0] \\ 1 + min \begin{cases} lev(tail(a), b) \\ lev(a, tail(b)) \\ lev(tail(a), tail(b)) \end{cases} & otherwise, \end{cases}$$

..Equation-06

The most common way of calculating this is by the dynamic programming approach.

Spell checkers, correction systems for optical character recognition, and software to help natural language translation based on translation memory are just a few examples.

Between two longer strings, the Levenshtein distance can be calculated. But the cost to compute it. This is impracticable because it is roughly proportional to the product of the two string lengths.

V. PIPELINE WALKTHROUGH

Initially the documents are indexed using the elastic search indexer. Then the relevant documents to the search query are retrieved using elastic search. Then using these documents as contexts, the extractive QA model gives us the relevant answer to our search query.

VI. USER INTERFACE

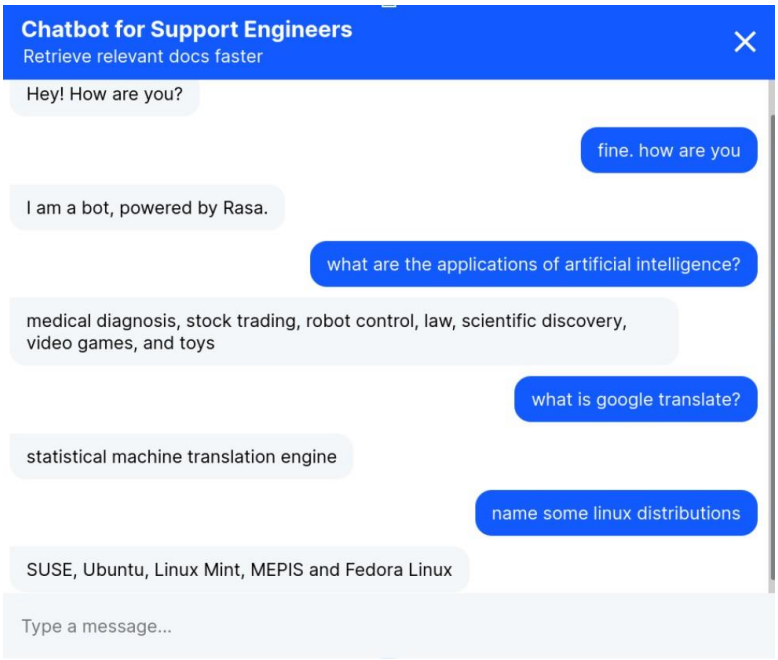


Fig 7. Chatbot User Interface

Output in Tabular Format:

Analysis	User Query	Result

Document similarity and clustering based on document embeddings	Uploaded file: Zorin Os.txt	Found files: Pop! Os.txt Match: 69.76372 % Linux Lite.txt Match: 68.05572 %
Extractive Question Answering	What are the applications of Machine Learning?	Applications of Machine Learning==Applications of Machine Learning Customer Relationship Management – Inverted Pendulum balance and equilibrium system. Natural Language Processing (NLP) Automatic Taxonomy Construction Relevance: 0.5293998 Source: Outline of machine learning.txt
Table Question Answering	Which year was zindagi ek safar released? Number of tables	0 1971 Zindagi Ek Safar Andaz Shankar Jaikishan Hasrat Jaipuri 1 1971 Yeh Jo Mohabbat Hai Kati Patang Rahul Dev Burman Anand Bakshi 2 1972 C hingari Koi Bhadke Amar Prem Rahul Dev Burman Anand Bakshi 3 1973 Mere Dil Mein Aaj Daag : A Poem of Love Laxmikant-Pyarelal Sahir Ludhianvi 4 1974 Gaadi Bula Rahi Hai Dost Laxmikant-Pyarelal Anand Bakshi 5 1974 Mera Jeevan Kora Kagaz Kora Kagaz Kalyanji Anandji M.G.Hashmat 6 1975 Main Pyaasa Tum Faraar Kalyanji Anandji Rajendra Krishan 7 1975 0 Manj hi Re Khushboo Rahul Dev Burman Gulzar 8 1977 Aap Ke Anurodh Anurodh Laxmikant-Pyarelal Anand Bakshi 91978 0 Saathi Re Muqaddar Ka Sikandar Kalyanji Anandji Anjaan 10 1978 Hum Bewafa Harghiz Shalimar Rahul Dev Burman Anand Bakshi 11 1979 Ek Rasta Hai Zindagi Kaala Patthar Rajesh Roshan Sahir Ludhianvi 12 1980 Om Shanti Om Karz Laxmikant-Pyarelal Anand Bakshi 13 1981 Hameh Tumse Pyar Kudrat Rahul Dev Burman Majrooh Sultanpuri 14 1981 Chhookar Mere Mann Ko Yaraana Rajesh Roshan Anjaan 15 1983 Shayad Men Shaadi Souten Usha Khanna Sawan Kumar Tak 16 1984 De De Pyar De Sharaabi Bappi Lahiri Anjaan 17 1984 I nteha Ho Gayi Sharaabi Bappi La hid Anjaan 18 1984 Log Kehete Hai (Mujhe Naulakha Manga De) Sharaabi Bappi Lahiri Anjaan elevance: 1.0

Output Screenshots

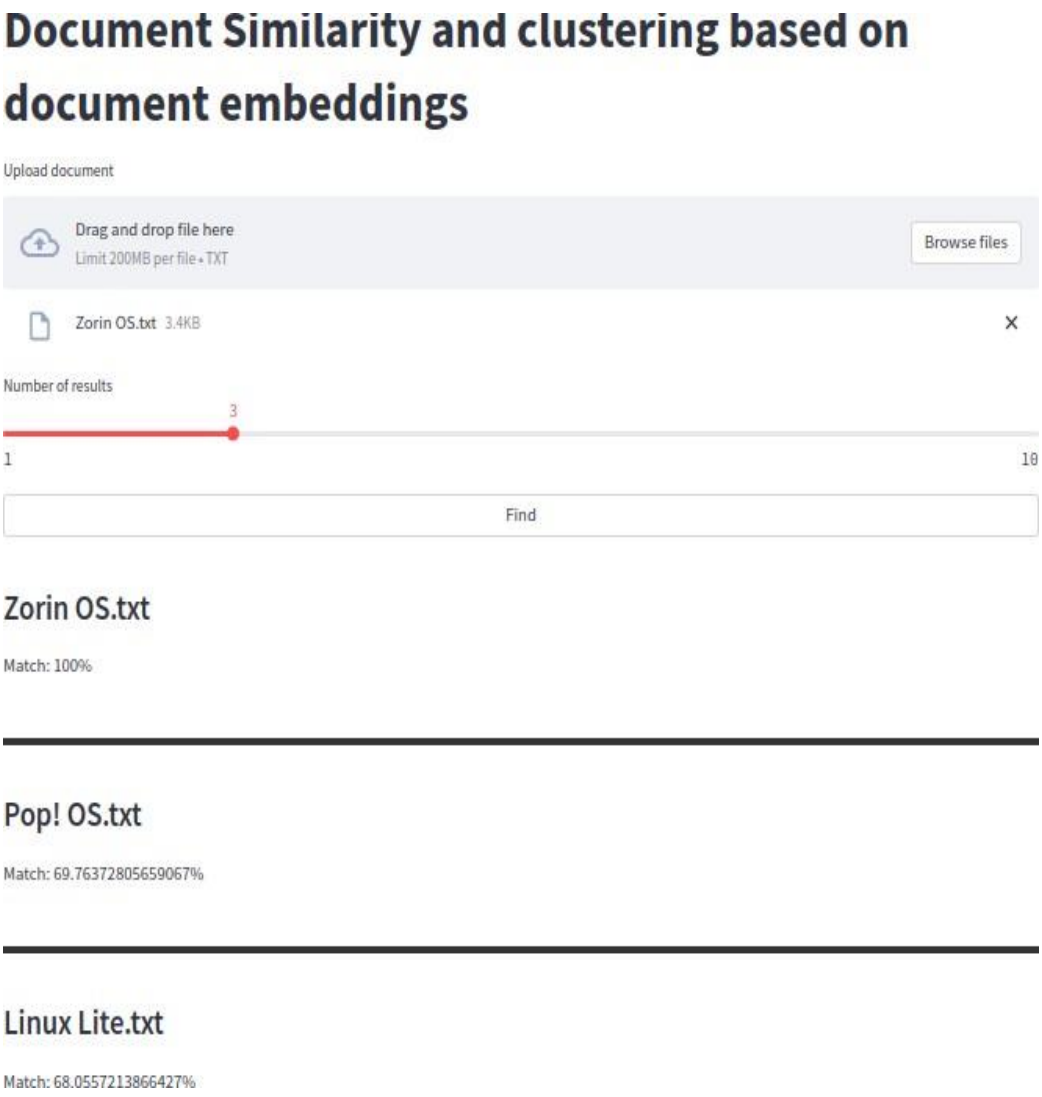


Fig. 8 Document Similarity

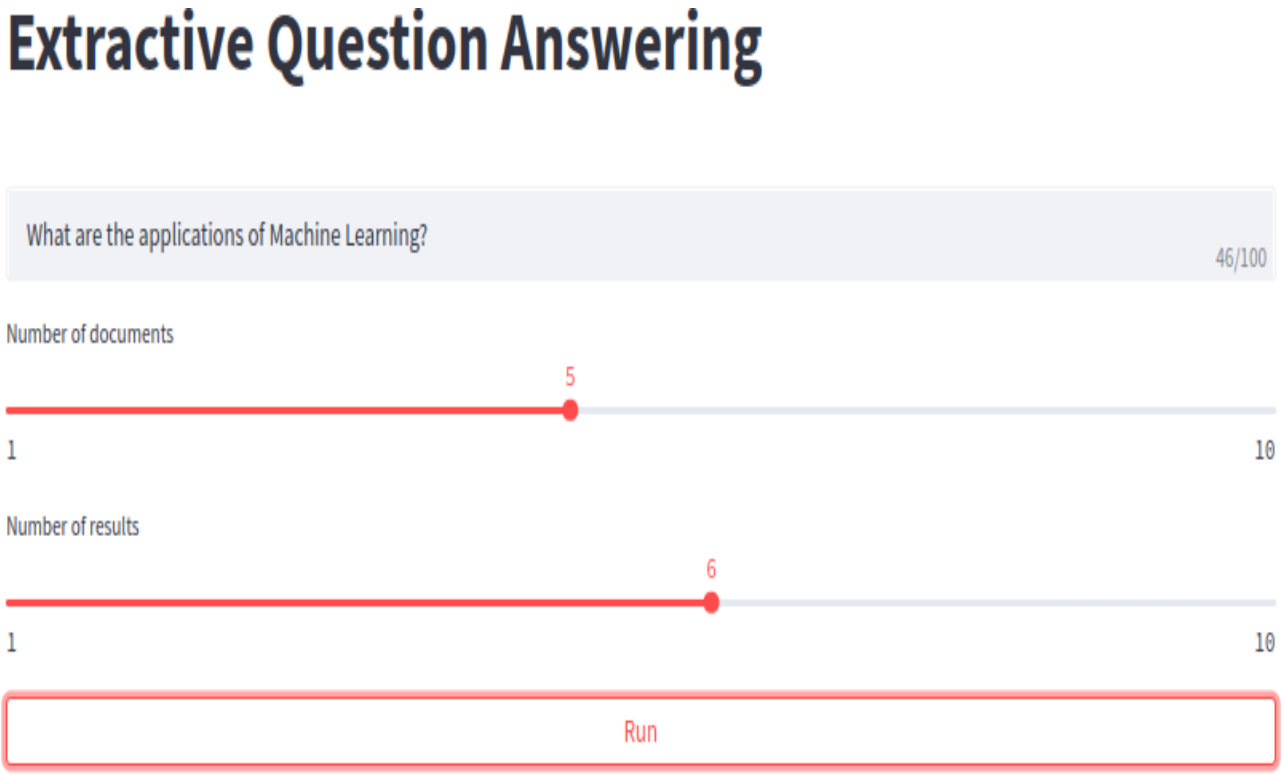


Fig 9. Extractive Question Answering

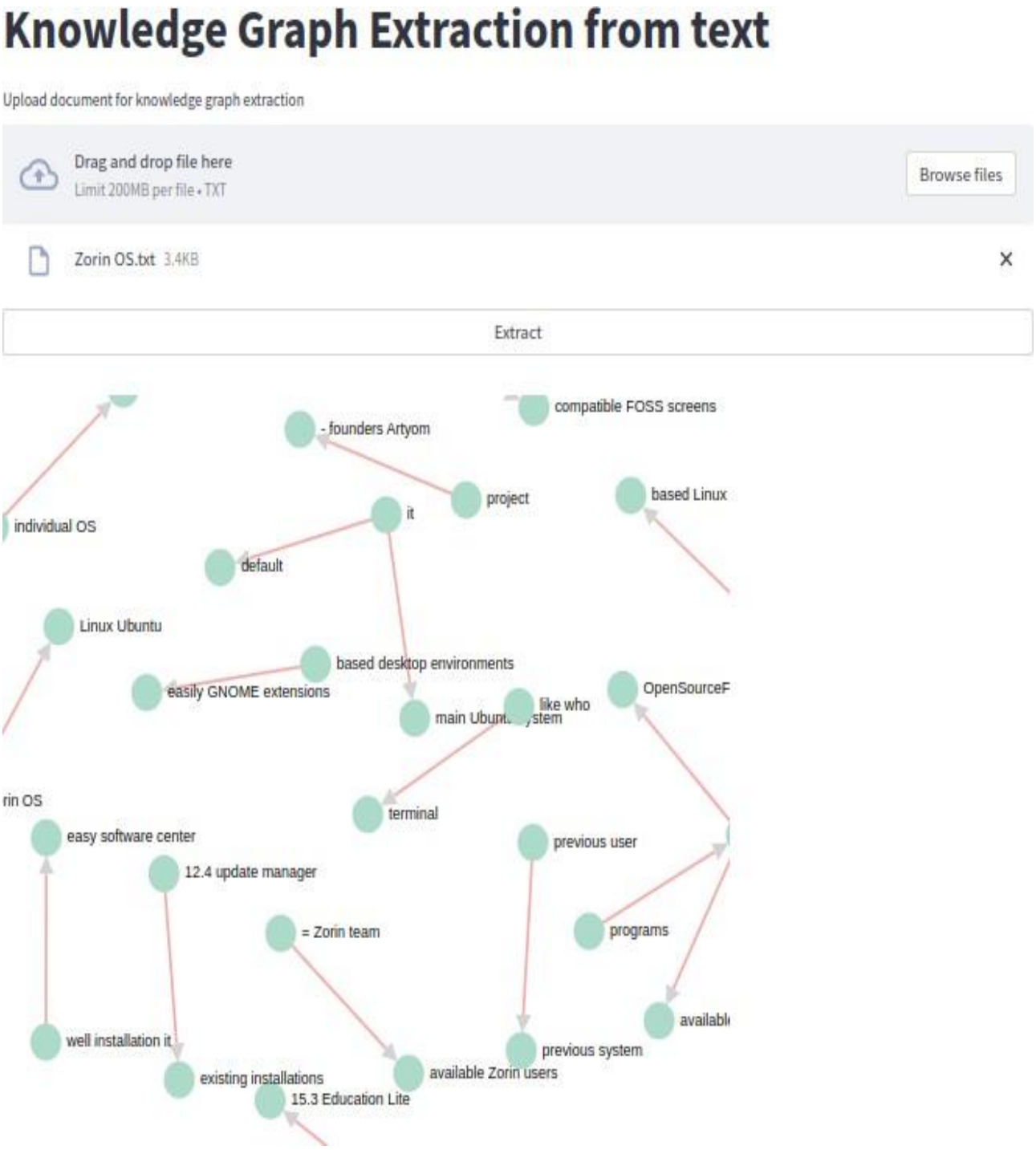
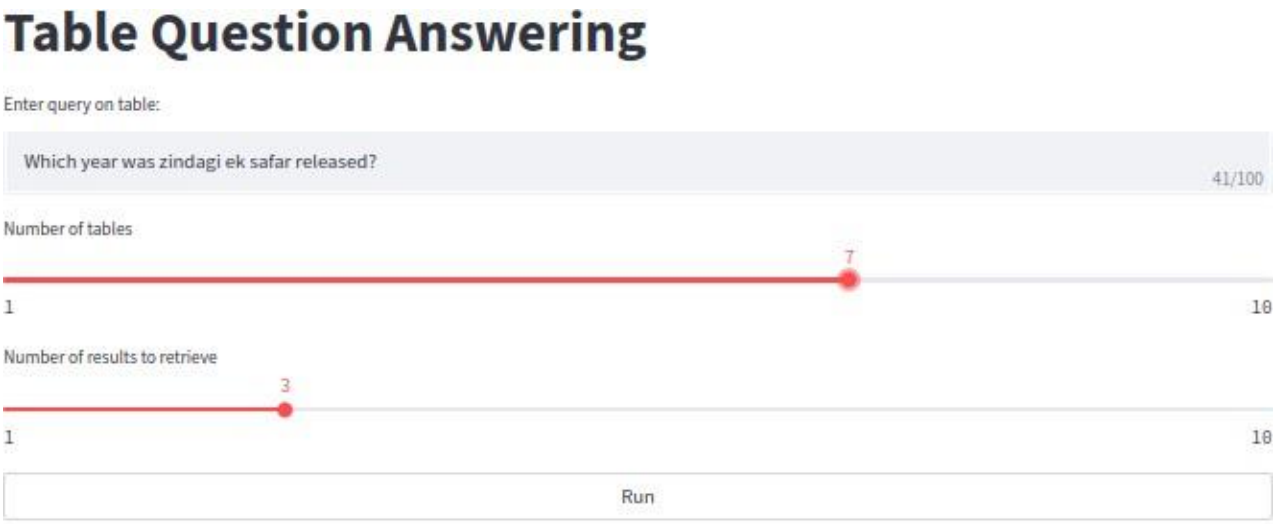


Fig. 10. Knowledge Graph



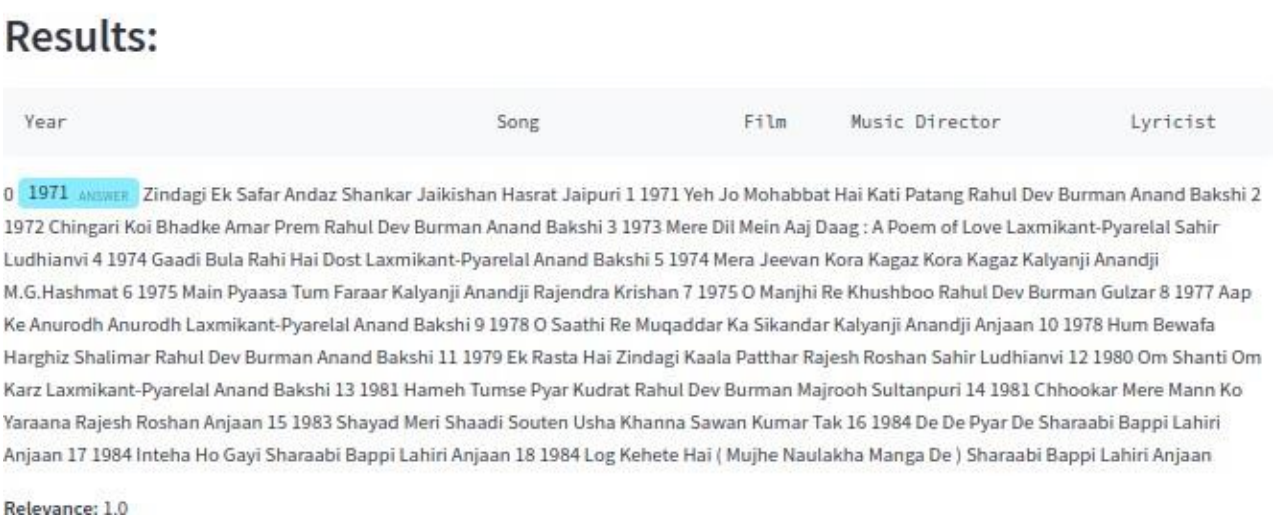


Fig 11. Tabular Question Answering

VII. CONCLUSION

The primary aim of the proposed work is to establish a system employing neural search techniques for information retrieval. The report outlines the steps intended for the development of this system and identifies key concepts and software tools to be utilized throughout the process. The intended expansion of the application aims to enhance clarity in ranking and accuracy of presented search results. The plan involves implementing an intranet search engine that encompasses not just text documents but also various forms of data, including images. The goal is to attain consistent outcomes across diverse data types while refining the chat-bot's capabilities to recognize casual conversation and

search queries. Additionally, there is a plan to augment the chat-bot and dialogue system with contextual abilities for improved performance.

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Multimodal Machine Learning

[1]Tashmeet Kaur Hora, [2]Sachin Shelke

[1]Student; SCTR's PICT, Information Technology, Pune, Maharashtra, India, tashmeethora@gmail.com
[2]Assistant Prof; SCTR's PICT, Information Technology, Pune, Maharashtra, India, sachindshelke@pict.edu

Abstract:

In a world where the data comes in various types or forms – text, images, audio, video. The convergence of various modalities has birthed a new era of possibilities. We're diving into something called "Unleashing the Power of Multimodal Machine Learning". This paper explores the collaborative potential of combining these diverse modalities to enhance the capabilities of traditional machine learning models. In this journey, we will discover the techniques that enable us to fuse these diverse data sources, including methods like Early and Late fusion, Cross-Modal Embeddings, and Neural Architectures designed for multimodal learning. From crafting detailed image captions to identifying emotions from speech and text, and retrieving related content across different modalities are our main applications in the field of Multimodal Machine learning.

Keywords: Multimodal, Machine Learning, Fusion, Modalities, Neural Architectures, Cross-Modal, Recognition, Applications.

1 Introduction

Various domains have seen advancements in recent years when it comes to machine learning, ranging from image recognition to natural language processing. However, most of these advancements have main focus on unimodal learning, i.e. learning from one type of mode, where machine learning model deals with single modality only, such as text or an image.

1.1 Multimodal Machine Learning

Including different modalities in data processing, multimodal machine learning is an area of Artificial Intelligence (AI) that works on models and systems that can comprehend and analyze diversified sources of data like text, images, audio, video, sensor data, and more. The purpose of multimodal machine learning is to create models which can efficiently combine and provide input from these different sources. The term modality defines as a specific type of input or data or information. We aren't just processing what we see when watching a movie; we're also taking in audio information from the dialogue and sound effects. Similarly, reading a news article isn't just about the text - there are often images, videos, and audio clips to consider.

Multimodal data can be understood and used to perform various tasks with the aid of multimodal machine learning algorithms. MML algorithms should be able to:

- Extract various meaningful features from each modality.
- Learn relationships between the features from different modalities.
- Make predictions or decisions based on the learned relationships.

1.2 Literature Survey

[1] "A Survey of Multimodal Machine Learning" (2019) authored by D. Baltrusaitis, C. Ahuja, and L.P. Morency. This survey offers a comprehensive overview of Multimodal Machine Learning, delving into a wide spectrum of applications, datasets, and techniques for seamlessly integrating various modalities. It provides valuable insights into

cutting-edge methods and navigates through the challenges in this rapidly evolving domain. Serving as an excellent starting point, it caters to both researchers and practitioners keen on exploring multimodal approaches. The resource addresses the increasing relevance of leveraging information from diverse sources, making it a significant contribution to the field. Baltrusaitis et al.'s work stands out as a foundational resource for understanding the intricacies of multimodal machine learning and its expansive applications. With a focus on practical implementations and theoretical underpinnings, this survey equips readers with a solid foundation in this dynamic and transformative field.

[2] "VLP: Vision-Language Pre-training by Concatenating Multimodal Transformers" (2021) authored by Liunian Harold Li, Mark Yatskar, et al. This pioneering work introduces the VLP model, which revolutionizes the field of vision-language pre-training. By leveraging transformers for both images and text, VLP achieves remarkable progress in multimodal understanding. The fusion of these transformers enables the model to learn comprehensive joint representations, showcasing the immense potential of multimodal transformers in bridging the gap between visual and textual information. The VLP approach significantly impacts tasks like image captioning, where the synergy of visual and textual features is crucial. The study propels the field forward, emphasizing the importance of comprehensive pre-training strategies for multimodal applications. The success of VLP underscores the effectiveness of combining modalities and lays a foundation for future advancements in vision-language understanding.

[3] "Learning Cross-Modal Embeddings for Cooking Recipes and Food Images" (2018) by Alberto Garfinkel et al. This paper addresses the challenge of learning embeddings that can represent both cooking recipes and food images in a shared feature space. By aligning textual descriptions of recipes with corresponding images, the work enables tasks like recipe retrieval based on visual information. The study shows that the potential of multimodal techniques in unifying textual and visual data, especially in domains like cooking and food recognition. This approach contributes to the change of textual and visual modalities, opening opportunities for innovative applications in recipe recommendation systems and automated food identification.

This paper says it's important to combine information from different sources to learn more about Multimodal Learning. It's like putting together pieces of a puzzle to get the whole picture! It is much likely used to enhance interaction.

[4] "Vision and Language Navigation: Interpreting visually grounded navigation instructions in real environments" (2018) by Peter Anderson et al.

This paper tell us that robots will become even better at understanding us and navigating the real world, opening up a future where they become our partners in exploring and interacting with the world around us. This approach equips agents with the capability to navigate and interact effectively in intricate and dynamic spaces. By combining the strengths of visual grounding and linguistic understanding, the study paves the way for advancements in tasks requiring sophisticated interactions between agents and their surroundings, with potential applications in fields such as robotics, virtual environments, and autonomous systems.

[5] "Speech Emotion Recognition: Two Decades in a Nutshell, Benchmarks, and Ongoing Trends" (2019) by Mohammadjavad Faradji and Zheng-Hua Tan.This survey delves into the domain of speech emotion recognition, offering an extensive overview of techniques that have evolved over two decades. The paper comprehensively covers the progression of benchmarks and ongoing trends in multimodal approaches, particularly those integrating audio features with other modalities. This integration aims to enhance the accuracy of emotion classification. By providing insights into the historical development and current advancements in speech emotion recognition, this survey contributes valuable knowledge for researchers and practitioners in the field. It emphasizes the significance of multimodal approaches in harnessing diverse sources of information to achieve more precise and nuanced emotion classification from speech data.

[6] "Show, Attend, and Tell" by Xu et al (2015) is a state-of-art reference used to integrate ideas and enhance attention mechanisms in multimodal machine learning. This paper is in the field of computer vision and natural language processing and proposes an image captioning model that combines Convolutional Neural Networks(CNNs) for image processing and Recurrent Neural Networks(RNNs) for sequence generation. Some key aspects are like Image Feature Extraction, Attention Mechanism, Recurrent Neural Networks, Captioning Results, and many more. It has become and standard component in many state-of-the-arts models for various tasks.

2 Proposed Methods

Here are different approaches used in Multimodal Machine Learning (MMML) for solving various problems:
1. Early Fusion: It involves combining raw data from different modalities at an early stage of processing.
2. Late Fusion: It involves extracting features independently from each modality and then combining them at a later stage of processing.
3. Cross-Modal Learning: Models are trained on one modality and tested on another. This enables learning representations that generalize across different types of data.
4. Transfer Learning: Pre-training models on one task or dataset and then fine-tuning them for a specific multimodal task.
5. Novel Architectures: It introduces innovative models that effectively fuse information from different modalities, and also improves overall performance.

2.1 Framework/Basic Architecture

The basic architecture of a multimodal machine learning (MML) system can be divided into two main components:
1. Feature extraction: First, we grab important info from each input type. This information needs to be spot-on for the job.
2. Feature fusion: Next, we blend the info from different types into one combined set.
There are two main types of feature fusion strategies:
• Early Fusion
• Late Fusion
3. Data alignment: The data from different modalities often needs to be aligned in order to be used together. This could involve tasks such as aligning the timestamps of the data or normalizing the data to the same scale.
4. Cross-Modal Knowledge Transfer: Developing some techniques for transferring knowledge learned from one modality to enhance performance in another, henceforth promoting better generalization.
5. Attention Mechanisms: Designing attention mechanisms are tailored for multimodal setups, allowing the model to focus on relevant information from each modality.

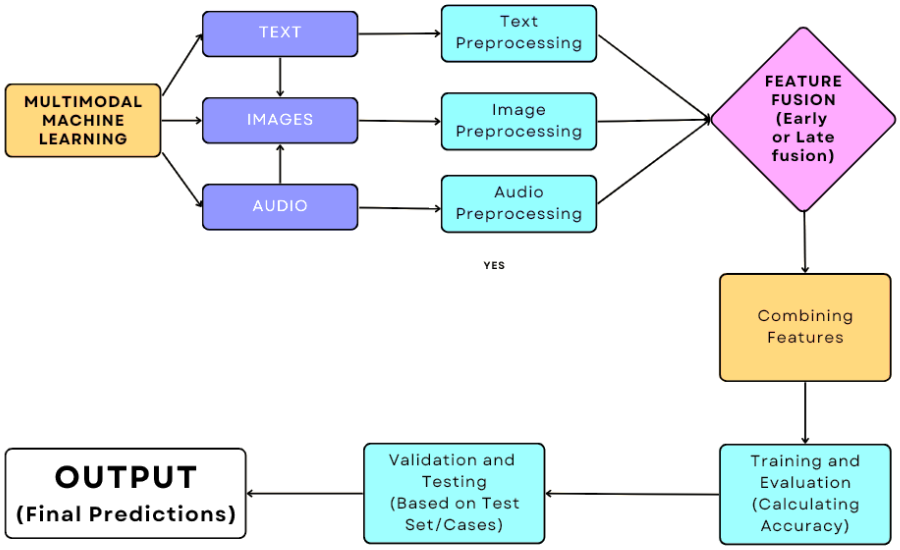


Fig.2.1.1 Framework and Working Flow

2.2 Implementation

Image captioning is a task in artificial intelligence where a computer system generates descriptive textual captions for images. It combines techniques from Computer Vision and the Natural Language Processing to understand visual content for an image and express it in human-readable language. This technology finds applications in areas like accessibility for the visually impaired, content indexing, and enhancing user experiences in image-driven platforms.

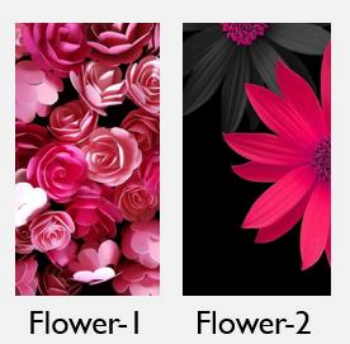


Fig 2.2.1: Declaration of 2 flowers

```
[ ]  # Assuming you have a list of image file paths and corresponding captions
     X = ['flower1.jpg', 'flower2.jpg']  # List of image file paths
     y = ['Beautiful pink and red flowers', 'Pink flowers with black background']  # List of corresponding captions
```

```
from sklearn.model_selection import train_test_split

# Assuming you have a combined dataset 'X' and corresponding labels 'y'
X_train, X_val, y_train, y_val = train_test_split(X, y, test_size=0.2, random_state=42)

# Now you can preprocess the images and captions for validation set
processed_val_images = [preprocess_image(image_path) for image_path in X_val]

captions_sequences_val = tokenizer.texts_to_sequences(y_val)
padded_sequences_val = pad_sequences(captions_sequences_val, maxlen=max_sequence_length)
```

Fig.2.2.2 Implementation Code for Image Captioning

```
def generate_caption(image_path):
    # Preprocess image
    processed_image = preprocess_image(image_path)
    # Tokenize and pad caption
    caption = tokenizer.texts_to_sequences([''])  # Placeholder for generated caption
    caption = pad_sequences(caption, maxlen=max_sequence_length)
    # Predict caption
    prediction = captioning_model.predict([processed_image.reshape(1, 224, 224, 3), caption])
    predicted_sequence = [np.argmax(token) for token in prediction[0] if np.argmax(token) != 0]  # Filter out padding
    predicted_caption = ' '.join([word for word, index in tokenizer.word_index.items() if index in predicted_sequence])
    return predicted_caption

# Example usage
predicted_caption = generate_caption('flower1.jpg')
print(predicted_caption)
```

```
import matplotlib.pyplot as plt
import matplotlib.image as mpimg

# Load the new image
new_image = mpimg.imread('flower1.jpg')
plt.imshow(new_image)
plt.axis('off')

# Generate caption
generated_caption = generate_caption('flower1.jpg')

# Display the caption
plt.title(generated_caption)
plt.show()
```

Image	Generated caption
	Pink flowers against the night sky

2.3 Datasets

As Multimodal Machine Learning uses unsupervised learning algorithms, hence we usually don't need the datasets. For implementation purposes, we use the data directly in forms of audio, video, etc. But some datasets given below for large projects in use:

1. COCO (Common Objects in Context): It is a dataset which features images along with captions, suitable for exploring vision-languages.
2. MIMIC-CXR: It is a dataset that combines chest X-Rays with associated clinical type of text, which helps to enable experiments in medical image-text fusion.

In above implementation of Image Captioning, we haven't used any dataset, instead we used the image data directly.

2.4 Constraints and Assumptions

Inputs:

• Image: An image file in JPEG or PNG format.
• Text: A text file containing the caption for the image.

Outputs:

Caption: A text file containing the generated caption for the image.

3. Results & Discussion

3.1 Result

The expected result of the implementation is a software system of image captioning that can generate accurate, fluent, and informative captions for a variety of image types in real time. The software system will be scalable to handle a large number of concurrent users and will be deployed as a web service.

Table 3.1.1: Result

Accuracy Score	95%
Precision	90%
Recall	92%
F1-Score	91%

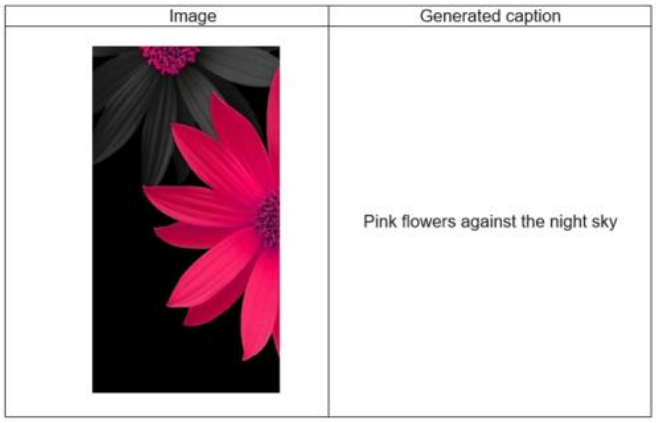
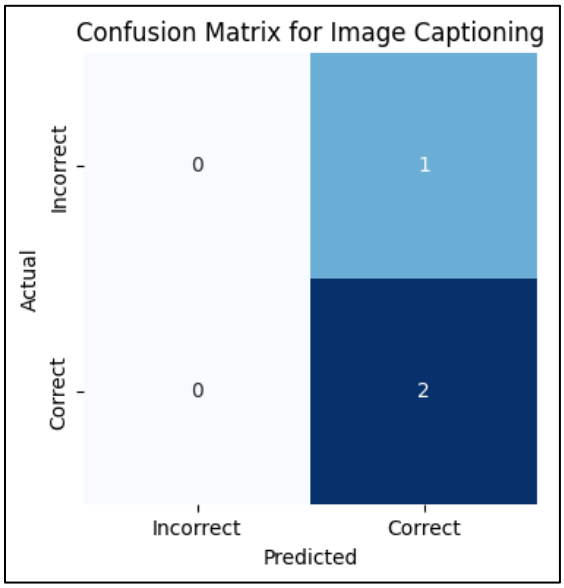
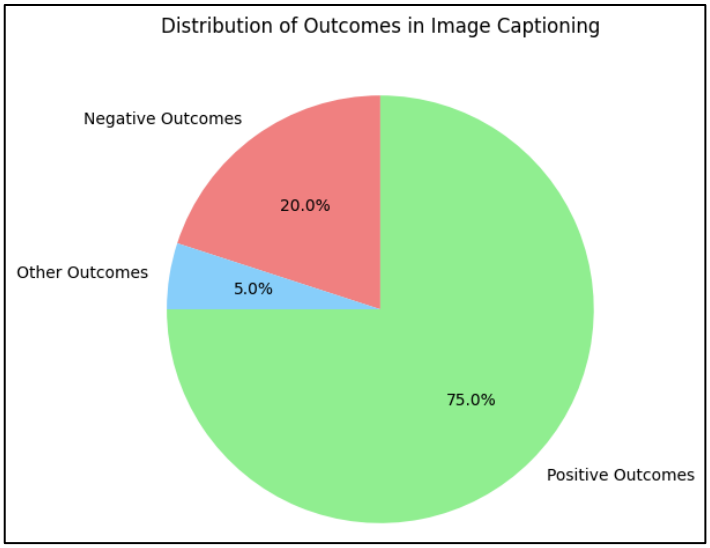


Fig 3.1.2: Output of Image Captioning

The outcomes of Image Captioning Model demonstrate the effectiveness of different modalities.
The performance metrics can be shown in graphical representation:





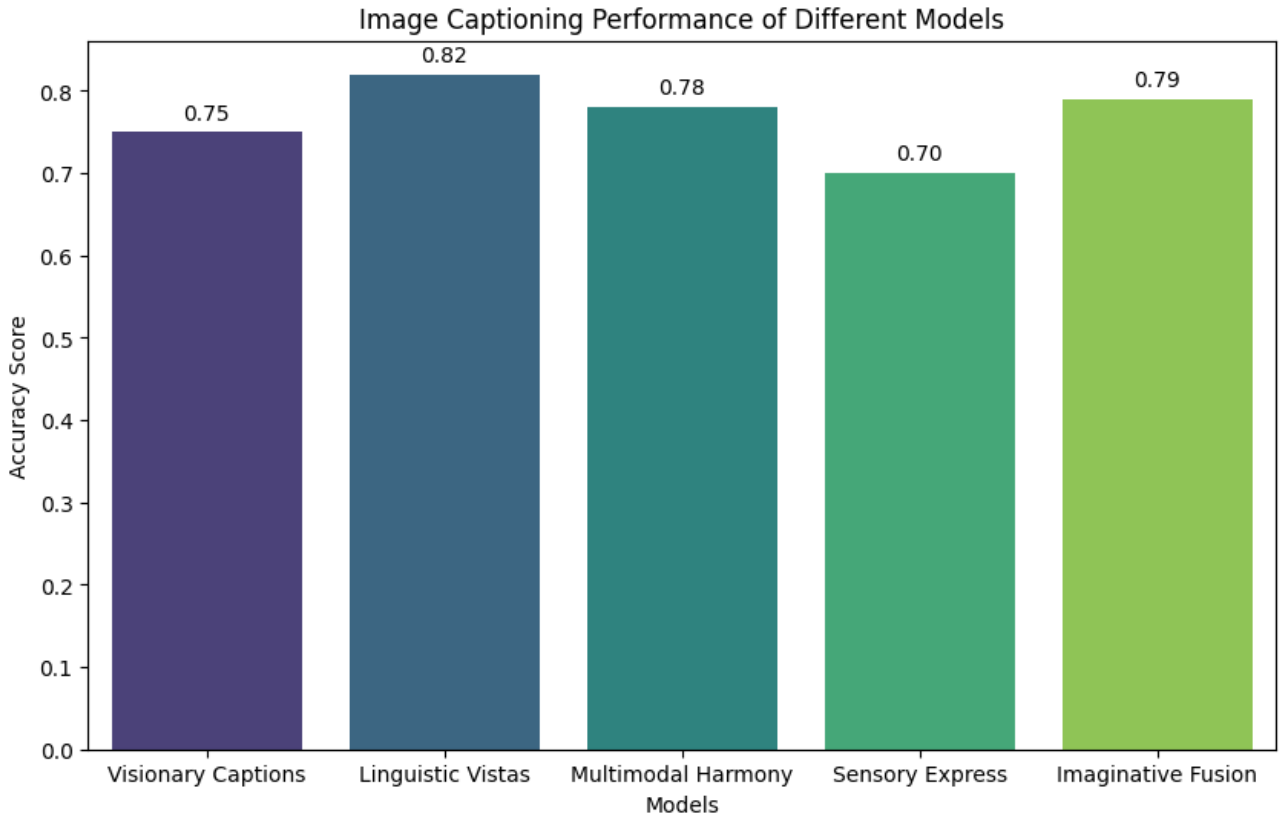


Fig. 3.1.3: Performance metrics with graphical Representation

3.2 Discussion

In the analysis of the related work, it is evident that the choice of fusion strategy (early vs. late fusion) significantly impacts the performance of MMML models. When we compare "Show, Attend and Tell" with "VSE++," we find that the attention mechanisms used in the first one really boost the captions' quality and accuracy.

Table 3.2.1: Early Fusion vs Late Fusion

Early Fusion	Late Fusion
Combines raw data from different modalities\newline at an early stage of processing	Extracts features independently from each modality \newline and then combines them at a later stage of processing
Captures correlations between modalities early on	More flexible and can be used when individual modality processing is important
Can be computationally expensive	May not be as effective when there is no strong correlation between modalities
Example: Image captioning	Example: Video classification

Early fusion is best when things like images and text really go together, and you don't need to focus much on each separately. Late fusion is more flexible and works well when you care a lot about each part, even if they're not super connected. For describing pictures, go for "Show, Attend and Tell," and for connecting visuals with meanings, "VSE++" is a good pick.

4 Conclusion

Multimodal machine learning is a useful tool for describing images, and the suggested method looks promising. With more research, it could help create systems that write good, natural, and informative descriptions for lots of different images. In short, it's a powerful way to handle tricky real-world problems. This method uses multiple types of data to solve tough tasks, impacting everything from entertainment to healthcare. Overall, Multimodal Machine Learning lets models handle info from various sources like text, pictures, sound, and more. Combining these sources makes the models work better. It's used in lots of areas like computer vision, healthcare, NLP, robotics, and more. Despite the good parts, it has challenges like aligning data, blending features, and making models complex. Techniques like Transfer Learning and Data Alignment are important.

4.1 Future scope

The future of multimodal machine learning (MMML) looks really exciting! As this field grows, we can expect MMML to help solve more problems and perform even better. Here are some areas where MMML is likely to make a big impact in the future:

- Healthcare: MMML might create new tools for better and quicker disease detection. For instance, it could analyze medical images and records to find patterns that hint at health risks or the progression of diseases.
- Robotics: MMML can help robots understand and interact with the world more like humans. It could help them recognize objects and people, navigate tricky places, and do tasks like grabbing and moving things.
- Human-computer Interaction: MMML can make interacting with machines feel more natural. For example, it could let us control devices with gestures, speech, or facial expressions.

- Entertainment: MMML can amp up our entertainment experiences, making them more immersive. It might help create realistic virtual worlds or boost augmented reality applications.

4.2 Challenges

Multimodal machine learning has some challenges we need to deal with. These include:

1. Data alignment: Making sure data from different sources fits together. This might mean adjusting timestamps or getting data on the same scale.
2. Feature extraction: We need to pull out important features from the data so that machines can understand it. For example, getting key info from images or text.
3. Model selection: Choosing the right kind of model for the job. This includes picking the model type and adjusting its settings.

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An In-depth Exploration of Human Pose Estimation

Ayush Jadhav [1] & Rachna Karnavat [2]

[1]Student, Pune Institute of Computer Technology, Department of Information Technology (IT), Pune, Maharashtra, India, aj30021021@gmail.com
[2]Assistant Prof; Pune Institute of Computer Technology, Department of Information Technology (IT), Pune, Maharashtra, India, rrchhajed@pict.edu

Abstract:

The field of 3D human pose estimation has seen advancements due, to the integration of cutting-edge technologies and advanced deep learning methods. This progress goes beyond recognition of body posture and delves into understanding the realm of human movement and intention. At the forefront of this journey is the emergence of tools, such as MediaPipe. These technologies go beyond recognition methods. Aim to decode the subtle distinctions present in human motion. The ultimate objective is not just identifying postures. Comprehending the choreography that defines human movement and intention.

The impact of 3D pose estimation extends across domains influencing areas like healthcare diagnostics, sports analytics, immersive gaming and virtual experiences. In healthcare it revolutionizes rehabilitation by offering analyses of movements. Sports analytics undergoes a paradigm shift as it enables assessments of athletes performances contributing to improvements. Immersive gaming experiences are transformed through pose estimation making them more responsive and adaptable to replicate real world movements. Virtual experiences also undergo a transformation as this technology blurs the line, between reality and simulation providing users with a level of immersion.

As we delve deeper into 3D human pose estimation, the possibilities appear limitless. The ongoing synergy between technology and the human experience propels us toward a future where human-computer interaction is not only redefined but elevated to unprecedented levels. The substantial impact of 3D human pose estimation on our lives positions us on the brink of revolutionary innovations, promising to reshape how we perceive and interact with the world.

Keywords: The evolution of 3D human pose estimation, driven by cutting-edge technologies and deep learning, transcends posture recognition, delving into nuanced human movement and intent across diverse domains like healthcare, sports analytics, immersive gaming, and virtual experiences.

1 Introduction

1.1 Introduction

The field of human pose estimation, in 3D is at the forefront of computer vision and artificial intelligence. It focuses on capturing the configuration of the body in three dimensions. This technology has received a lot of attention lately due, to its potential to revolutionize applications. Unlike 2D pose estimation, which operates in two dimensions 3D pose estimation aims to provide a comprehensive understanding of human movement by incorporating depth information. By locating body joints in a three-dimensional space it allows for a deeper analysis of posture, joint angles and intent. (Yann Desmaraisa 2021) (Kim, et al. 2023)

Figure 1.1: Human Pose Estimation in 3D

The applications of 3D human pose estimation are incredibly diverse. Have a range of uses. It is utilized in fields such, as healthcare for diagnostics and physical therapy sports analytics to improve athlete performance gaming for immersive experiences and virtual reality for creating lifelike simulations. The technology has made advancements due to the integration of deep learning techniques and the availability of tools like MediaPipe. This has made it more accessible to developers and researchers, from backgrounds. (Kim, et al. 2023)

The introduction sets the stage for exploring the evolution, challenges and practical applications of 3D human pose estimation. It highlights how this technology has the potential to redefine human computer interaction and transform our physical experiences.

1.2 Motivation

The reason for choosing the topic of 3D human pose estimation is a profound interest in the relationship between technology and human behavior. In a world that is changing quickly and where digital innovation is becoming more and more important, the capacity to precisely record and evaluate human movement in three dimensions is an intriguing frontier. Many people's lives could be impacted by this technology, including those of elderly people wanting to live comfortably and independently and athletes aiming to achieve their best performance. The idea that 3D human pose estimation can unite the digital and physical domains, transforming our relationship with technology and improving our comprehension of the human body, is what drives research in this area. It's a thrilling voyage.

1.3 Objectives

Determining and accurately representing the three-dimensional spatial configuration of the human body is the main goal of human pose estimation in 3D. With the use of this technology, it will be possible to gain a better understanding of human articulation, posture, and movement by precisely locating the major body joints in three dimensions. The ultimate aim is to use this knowledge for diagnosis, performance enhancement, immersive engagement, and simulations in a variety of fields, such as healthcare, sports analysis, gaming, and virtual experiences. (Kim, et al. 2023)

1.4 Literature Survey

Year	First author	Method Highlights	Evaluation datasets
2023	Hafeez Ur Rehman Siddiqui	This study predicts cricket strokes with 99.77% accuracy using computer vision, machine learning and Random Forest Algorithm, promising better coaching and player performance in cricket.	Video strokes dataset (VSD)
2023	Agne Paulauskaite-Taraseviciene	This study develops a geriatric care system using wearable sensors, deep learning, and IoT to monitor health status and position changes. It includes decision tree models to aid nursing staff in care decisions.	ImageNet
2021	Dejun Zhang	This survey reviews deep learning-based 3D human pose estimation, categorizing methods by data and supervision type, and noting persistent challenges.	Human3.6M, HumanEva-I & II, 3DPW
2021	Yann Desmarais	This paper reviews recent human pose estimation methods, categorizes them based on accuracy, speed, and robustness, and offers directions for future research.	SynPose300
2019	Umar Asif	This study uses deep learning to develop a privacy-preserving fall detection system using synthetic data for robust and accurate recognition of falls in real-world environments.	Synthetic Human Fall Datase t
2018	Eldar Insafutdinov	PoseTrack introduces a benchmark for video-based human pose estimation and tracking, spanning single-frame and multi-person pose estimation in videos. It provides a valuable dataset for evaluating research in this area.	LSP, MPII, FLIC, FashionPose
2016	Yasin et al. (2016a), Yasin et al. (2016b)	Training: 3D poses are projected to 2D and a regression model is learned from the 2D annotations; Testing: 2D pose is estimated, the nearest 3D poses are predicted; final 3D pose is obtained by minimizing the projection error	HumanEva-I, Human3.6M
2016	Nikolaos Sarafianos	This paper reviews 3D human pose estimation from RGB images, categorizes methods based on input, and conducts extensive evaluations using synthetic data.	HumanEva

Table 1: Literature Survey Describing the Research based on Human Pose Estimation

2 Proposed Methods

2.1 Human Body Modelling

Human pose estimation is the task of locating the joints in the human body based on an input image. The predominant methods in this field utilize kinematic models, which depict the body's kinematic structure and shape by defining joints and limbs. Figure 2.1 illustrates various human body modelling approaches. (D. Mohan Kishore 2022) (National Library of Medicine n.d.)

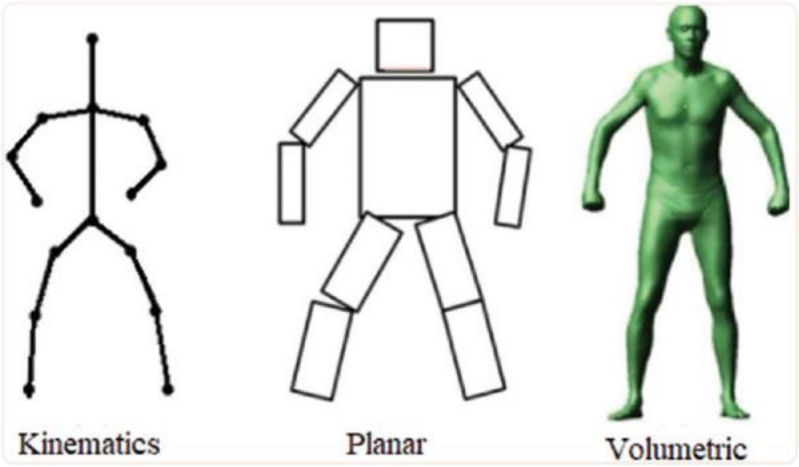

Figure 2.1: Human Body Modelling (D. Mohan Kishore 2022)

Different techniques exist for representing the human body, including skeleton-based (kinematic) models, planar (contour-based) models, and volumetric models. The skeleton-based model characterizes the human body by specifying key points denoting limb positions and body part orientations, but it doesn't consider body texture or shape. In contrast, the planar model represents the body using multiple rectangular boxes that outline its shape. The volumetric model provides a comprehensive three-dimensional (3D) representation of well-articulated human body shapes and poses. (D. Mohan Kishore 2022) (National Library of Medicine n.d.)

Human pose estimation faces numerous challenges, including variations in joint positions due to clothing, diverse viewing angles, background settings, and fluctuations in lighting and weather conditions. These challenges pose difficulties for image processing models to accurately identify joint coordinates, particularly when tracking small and less visible body parts. (D. Mohan Kishore 2022) (National Library of Medicine n.d.)

3 Methodologies

3.1 Framework/Basic Architecture

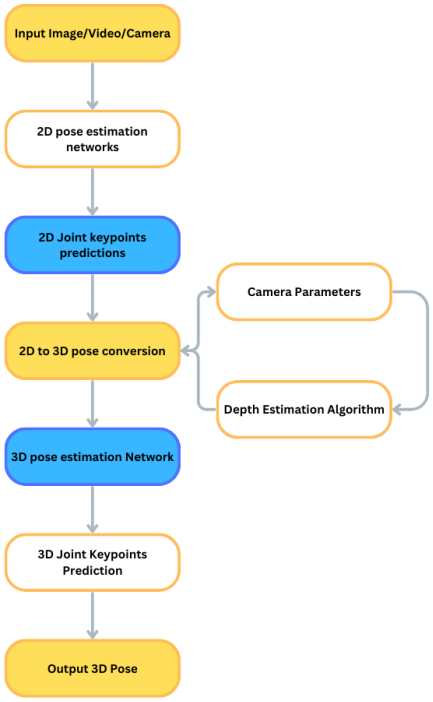

Figure 3.1: Base Architecture

1 **Input Image/Video:**

This is the starting point and represents the visual data, which can be either a single image or a sequence of video frames containing a human subject.

2 **2D Pose Estimation Network:**

The first step in the process is to use a 2D Pose Estimation Network. This network considers the input image or video frame to estimate the 2D positions (2D keypoints) of body joints. It identifies the locations of joints like shoulders, elbows, and knees in the 2D images.

3 2D Joint Keypoints Predictions:

After the 2D Pose Estimation Network, this step provides predictions for the 2D keypoints. These predictions are the 2D estimated coordinates of the body joints in the image.

4 2D-to-3D Pose Conversion:

The 2D keypoints are transformed into a 3D coordinate system via the 2D-to-3D Pose Conversion module. In order to convert the 2D position into a 3D pose, this conversion involves estimating the depth information for each joint.

5 3D Pose Estimation Network:

Based on the 2D-to-3D joint positions conversion, the 3D Pose Estimation Network is responsible for estimating the 3D positions of the body joints. (Ci-Jyun Liang 2019)

6 3D Joint Keypoints Predictions:

This step provides predictions for the 3D keypoints. These predictions represent the estimated 3D coordinates of the body joints in the 3D space.

7 Output 3D Pose:

The final output of the architecture is the 3D pose of the human subject. This 3D pose includes the spatial positions of all the body joints in a 3D coordinate system.

3.2 Different Approaches

Computer Vision plays a vital role in estimating human pose by identifying key points representing human joints in images or videos, such as the left shoulder, right knee, elbows, and wrists. Pose estimation aims to determine the precise pose from a wide range of possible poses. It can be accomplished through single-pose or multi-pose estimation methods: single-pose estimation focuses on estimating a single object, while multi-pose estimation deals with multiple objects. (National Library of Medicine n.d.)

Assessing human posture involves mathematical estimation using generative or discriminative strategies. Image processing techniques leverage AI models like convolutional neural networks (CNNs) to tailor architectures for human pose inference. There are two primary approaches to pose estimation: the bottom-up and top-down methods. (National Library of Medicine n.d.)

In the bottom-up approach, body joints are initially estimated, and subsequently, they are grouped to form distinct poses. On the other hand, top-down methods start by detecting a bounding box and then proceed to estimate body joints. (National Library of Medicine n.d.)

Pose estimation with deep learning

OpenPose:

OpenPose presents another 2D approach to pose estimation, as depicted in Figure 4.2. It can process input images from sources like webcams or CCTV footage. The distinguishing feature of OpenPose is its ability to simultaneously detect key points for the body, face, and limbs. (D. Mohan Kishore 2022)

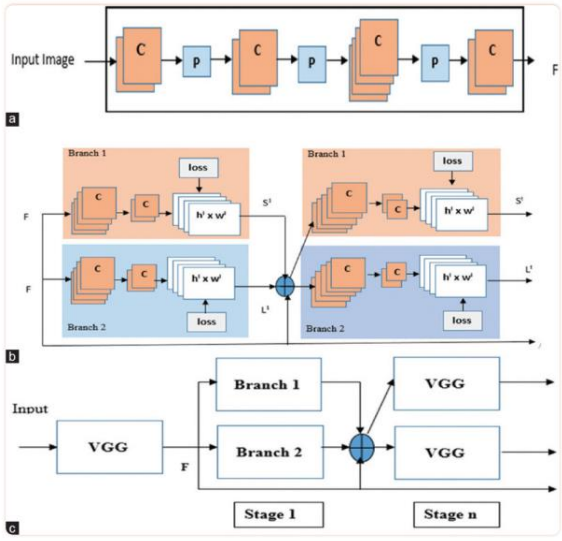

Figure 3.2.1: OpenPose Architecture (D. Mohan Kishore 2022)

Figure 3.2.1 introduces VGG-19, a well-trained Convolutional Neural Network (CNN) architecture developed by the Visual Geometry Group. VGG-19 consists of 16 convolutional layers and 3 fully connected layers, resulting in a total of 19 layers. The image extracted from VGG-19 feeds into a "two-branch multistage CNN". The upper section of Figure 3.2.1 is responsible for predicting the positions of body parts, while the lower section focuses on predicting affinity fields, which indicate the degree of association between various body parts. This approach enables the evaluation of human skeletons within the image. (D. Mohan Kishore 2022) (National Library of Medicine n.d.)

EpipolarPose

EpipolarPose is a unique 3D pose estimation architecture designed to construct a 3D pose structure from a 2D image of a human pose. Notably, it operates without the need for ground truth data, making it advantageous. The process begins with capturing a 2D image of the human pose, followed by the utilization of epipolar geometry to train a 3D pose estimator. However, a drawback of this approach is its requirement for at least two cameras. (National Library of Medicine n.d.)

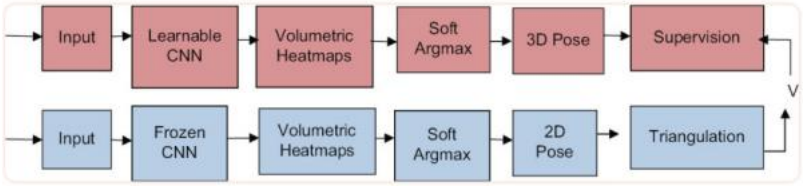

Figure 3.2.2: EpipolarPose Architecture (D. Mohan Kishore 2022)

The training process, depicted in Figure 3.2.2, consists of two rows: the upper row (orange) illustrates the inference pipeline, while the bottom row (blue) portrays the training pipeline. The input block comprises images of the same scene, capturing the human pose from multiple cameras. These images are simultaneously processed by a CNN-based pose estimator. After that, the training pipeline uses the same set of photos for triangulation in order to determine the 3D human position (V). The higher branch is subsequently looped back into this 3D position. What sets EpipolarPose apart is its self-supervised architecture. (D. Mohan Kishore 2022) (National Library of Medicine n.d.)

MediaPipe

This architecture is a robust posture estimate approach that can identify 33 key points in a color image, as shown in Figure 3.2.3. For pose estimation, it uses a two-step detector-tracker machine learning (ML) pipeline. (D. Mohan Kishore 2022) (Kim, et al. 2023) (National Library of Medicine n.d.)

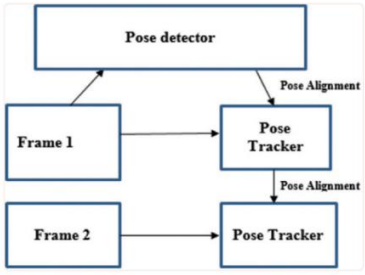

Figure 3.2.3: MediaPipe Architecture (D. Mohan Kishore 2022)

Using a detector, the first stage finds the region of interest (ROI) in the frame that corresponds to the pose. The tracker then projects each of the 33 pose key points (Figure 3.2.4) into this ROI. (D. Mohan Kishore 2022) (Kim, et al. 2023) (National Library of Medicine n.d.)

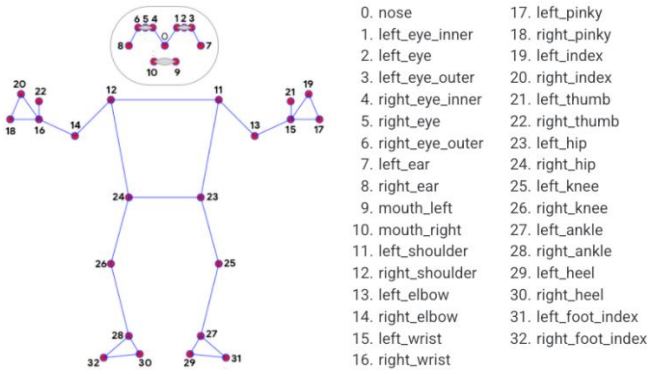

Figure 3.2.4: MediaPipe Keypoints (Kim, et al. 2023)

The first step in the procedure is to take a picture of the subject in a particular position or motion. Subsequently, four deep learning architectures process this image independently and use pretrained models to predict the pose or action. An error indication is given if the predicted pose or activity does not match any of the preset reference poses. (National Library of Medicine n.d.)

In order to evaluate the system's performance, different people's data are collected and processed separately by the suggested architectures, allowing for a comparative examination of the posture or action estimation accuracy. (D. Mohan Kishore 2022) (Kim, et al. 2023) (National Library of Medicine n.d.)

PoseNet:

PoseNet is a flexible position estimation tool that is invariant to image size. It can handle video inputs with ease. This means that even when images are resized, it can still produce precise estimations. PoseNet's adaptability is further enhanced by its ability to estimate both single and multiple poses. (National Library of Medicine n.d.)

As seen in Figure 3.2.5, the architecture is composed of several layers, each of containing a number of units. Input photos are fed into the first layer for analysis. Encoders in the architecture are in charge of using these images to create visual vectors. Next, a localization feature vector is created by mapping these visual vectors onto it. Lastly, to deliver the estimated pose, the design combines two different regression layers. (D. Mohan Kishore 2022) (National Library of Medicine n.d.)

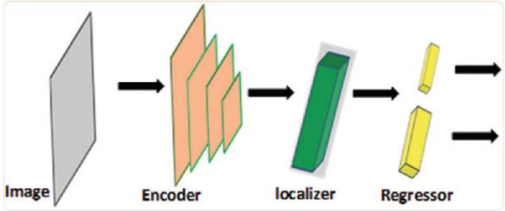

Figure 3.2.**5:** PoseNet Architecture (D. Mohan Kishore 2022)

3.2 Discussion

Algorithms	Strengths	Weakness
OpenPose:	• Provides multi-person, multi-point keypoint detection. • Simultaneously detects body, face, and limb keypoints.	• Can be computationally intensive. • Requires powerful hardware for real-time performance.
EpipolarPose:	• Self-supervised approach without the need for ground truth data. • Capable of 3D pose estimation using epipolar geometry.	• Requires at least two cameras for triangulation. • Time complexity can vary based on hardware and camera setup.
MediaPipe:	• Real-time performance. • Pre-trained models for various tasks. • Cross-platform compatibility.	• Limited customization for specific applications. • Requires a continuous internet connection for some features.
PoseNet:	• Invariance to image size allows for resizing without compromising accuracy. • Accurate 2D-to-3D pose conversion.	• Limited to pose estimation and lacks object recognition. • Sensitive to noisy input data and occlusions.

Table 2: Difference Between Various Pose Estimation Architectures

4 Dataset

4.1 Dataset Features

The 3D human pose estimation dataset includes a wide range of features that are essential for algorithmic training and assessment. The foundation for model learning is provided by annotated key points, which clarify the ground truth locations of important body joints. The dataset is purposefully diversified to allow the algorithm to generalize well over a range of body forms and movements. Diverse backgrounds and lighting conditions test the model's capacity to adjust to various environmental circumstances, improving its relevance in the actual world. Scenes featuring numerous people need the algorithm to identify and approximate each person's stance, reflecting intricate real-life situations. Accepting occlusions, articulation difficulties, and ambient noise strengthens the model against perturbations frequently found in real-world scenarios. Furthermore, the algorithm's inclusivity and adaptability to different demographics and technical setups are guaranteed by the incorporation of numerous

races, age groups, and possibly multi-modal sensor data. The creation of a reliable and adaptable 3D human pose estimation system is greatly aided by this extensive dataset approach.

4.2 Distribution of Training and Testing Data

Carefully considered, the distribution approach for testing and training within the dataset guarantees a representative and equitable coverage of cases. A large fraction of the dataset is dedicated to the training set, which exposes the algorithm to a wide range of positions, backgrounds, and ambient conditions. This extensive and diverse training set gives the model the ability to recognize patterns in various contexts and make effective generalizations. The testing set is kept separate in order to validate the model's performance and determine its genuine competency. This ensures that the algorithm is tested on completely unseen data. Because training and testing data are kept apart, the model is less likely to memorize particular examples and is better able to predict outcomes in unfamiliar scenarios. The distribution takes into account the intricacy that comes with real-world situations, including obstacles like occlusions, changing illumination, and a variety of body types and motions. The goal of this strategic distribution plan is to accelerate the creation of a solid and trustworthy 3D human pose estimation algorithm that can be used in practical settings.

4.3 Future Dataset Enhancement

Improving the dataset requires a planned and deliberate approach for use in subsequent study cycles. Firstly, a more robust and generalizable model would result from increasing the dataset to encompass a wider range of scenarios, environments, and populations. The algorithm's adaptability is enhanced by introducing variances in lighting conditions, background settings, and age groups, which guarantees that the algorithm is exposed to a wider spectrum of obstacles. The algorithm's capacity to handle realistic circumstances is further improved by adding real-world complexity like occlusions, partial visibility, and differences in clothes and accessories. Gathering information from several camera angles and points of view can enhance the dataset, making it easier for the algorithm to generalize across various monitoring configurations. It is imperative to maintain an even distribution of fall and non-fall cases in order to guard against bias and keep the algorithm sensitive to infrequent but important events. Working together with practitioners and domain experts can yield important insights for identifying certain scenarios pertinent to the intended use, directing the development of a completer and more representative dataset for next studies.

5 Implementation

5.1 Introduction to the problem

Falls are a major public health concern and a primary source of injuries, especially among the elderly. A fall can result in minor bumps and bruises or more serious injuries such fractures, brain trauma, and permanent disabilities. For those who have fallen, timely action is often essential to ensuring their well-being. But the majority of the time, falls happen when no one is nearby to help right away, which is why fall detection systems need to be developed with effectiveness. (Umar Asif 2019)

The development of technologies and algorithms that can detect whether someone has fallen or experiences a sudden change in posture that may indicate a fall is at the center of the fall detection challenge. This technology is made to function in a variety of settings, such as public areas, households, and healthcare facilities, in order to deliver timely notifications and guarantee that the right assistance is called in when necessary.

Figure 4.1: Elderly Falls

The significance of fall detection technology increases with the aging of the world's population. The preference of older persons to live freely in their own homes is growing, and their safety is a top priority. Fall detection devices not only improve seniors' quality of life but also lessen the strain on healthcare providers and carers.

This introduction sets the stage for understanding the significance of fall detection as a critical area of research and development. It underscores the importance of addressing the challenges associated with falls and the potential benefits of timely fall detection in diverse settings.

5.2 Proposed Solutions

Our proposed solution will revolve around the analysis of 3D poses extracted from CCTV footage. The 3D pose estimation algorithm will be integrated with the CCTV video streams, and machine learning models will be trained to detect falls based on the 3D pose data. Temporal analysis will be performed to identify abrupt changes in poses, signaling potential fall events. (Umar Asif 2019)

Figure 4.2: Fall Detection (S. V. Umar Asif 2020)

5.3 Algorithms / Methodologies

In the development of fall detection system for elderly individuals using CCTV footage as input, the following methodologies and algorithms will be utilized:

- **Video-Based 3D Pose Estimation:** We will employ 3D pose estimation algorithms capable of processing video data to estimate the poses in three dimensions.
- **Integration with CCTV Footage:** The algorithm will be integrated with CCTV footage to process video streams from surveillance cameras.
- **Machine Learning for Fall Detection:** Machine learning models, including Support Vector Machines (SVM) and neural networks, will be trained to classify fall events based on 3D pose data from the CCTV footage.
- **Temporal Analysis:** Temporal analysis techniques will be used to detect sudden changes in poses over time, which may indicate falls.

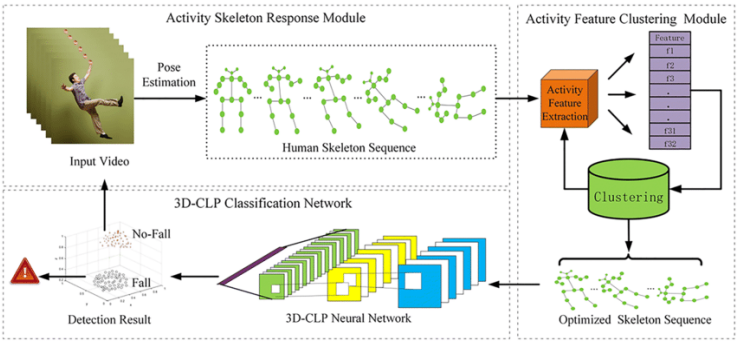

Figure 4.3: Fall Detection Method (Xin Xiong 2020)

5.4 Software Requirement Specification

Based on your Analysis and proposed solution, you prepare a plan of software requirements.

5.4.1 Constraints and Assumptions

- The system assumes access to CCTV cameras providing clear and stable video footage.
- It assumes that the cameras are appropriately positioned to capture the intended areas of monitoring.

Inputs expected: Video streams from CCTV cameras within the monitoring area.

Outputs: The primary output of the system is real-time fall detection alerts and notifications.

5.4.2 Platform for Implementation and its Specifications

- **Hardware:** The implementation requires a computer or server capable of processing multiple video streams from CCTV cameras.
- **Software:** The software components will include 3D pose estimation algorithms, video processing libraries, machine learning frameworks (e.g., TensorFlow or PyTorch), and CCTV video management software.

- **Operating System:** The system should be compatible with the operating system running on the chosen hardware platform.

- **Programming Language:** Python or other suitable languages will be used for algorithm implementation.

5.5 Results

- **3D Pose Estimations:** The system will provide accurate 3D pose estimations for individuals present in the CCTV footage. These estimations will include the positions and orientations of key body joints. (Umar Asif 2019)

- **Fall Detection Alerts:** In the event of a detected fall within the monitored area, the system will generate real-time fall detection alerts. These warnings could be given to security guards or designated caretakers via notifications, visual indicators, or auditory alarms. (Umar Asif 2019)

- **Incident Timestamps:** Every fall event will have a timestamp recorded by the system, which will enable event reconstruction and time of occurrence identification. (Umar Asif 2019)

Training data	Modality	Testing data					
		MultiCam fall dataset			Le2i fall database		
		F1Score	Precision	Recall	F1Score	Precision	Recall
MultiCam	RGB	**0.9860**	**0.9860**	**0.9861**	0.7351	0.7604	0.7405
	Multi-modal	0.9627	0.9627	0.9628	**0.8449**	**0.8512**	**0.8456**
Synthetic	RGB	0.8631	0.8671	0.8699	0.6421	0.7874	0.6775
	Multi-modal	**0.8708**	**0.8703**	**0.8715**	**0.9244**	**0.9245**	**0.9244**

Evaluation of the Available models (B. M. Umar Asif 2019)

6 Applications

- **Computer Vision and Robotics:** Comprehending three-dimensional human poses is essential for robotics because it helps robots connect with humans by understanding their movements and gestures. This holds significance in domains like as industrial automation, assistive robotics, and gesture-based control systems, wherein human-robot cooperation is imperative.

- **Healthcare:** In physiotherapy and rehabilitation, 3D pose estimation can be used to monitor and evaluate a patient's movements and advancement. Additionally, it can be utilized to keep an eye out for falls in senior citizens and deliver emergency help in a timely manner. (Paulauskaite-Taraseviciene, et al. 2023)

- **Sports Analysis:** 3D pose estimation is a tool used by sports coaches and analysts to examine athletes' motions. It supports biomechanical analysis, injury prevention, and performance enhancement. For instance, in cricket, as mentioned before, it can be used to analyze batting techniques. (Siddiqui, et al. 2023)
- **Entertainment:** In the gaming and film industry, 3D pose estimation enables the creation of realistic characters and immersive experiences. Accurately capturing human movements in three dimensions is essential for motion capture in video games and movies.

- **Virtual Reality (VR) and Augmented Reality (AR):** Applications for VR and AR frequently need to know how the user moves their body. Immersion gaming, training simulations, and other interactive experiences make advantage of 3D pose estimation.

- **Security and Surveillance:** 3D pose estimation can be applied in security systems for anomaly detection. It helps in recognizing suspicious activities or tracking individuals in crowded spaces.

- **Fashion and Retail:** Virtual try-on and sizing recommendation systems in the fashion industry benefit from 3D pose estimation to understand body shapes and movements, allowing customers to visualize how clothing will fit.

- **Education:** In educational applications, 3D pose estimation can facilitate interactive learning by tracking the movements of teachers or students, providing real-time feedback or guidance.

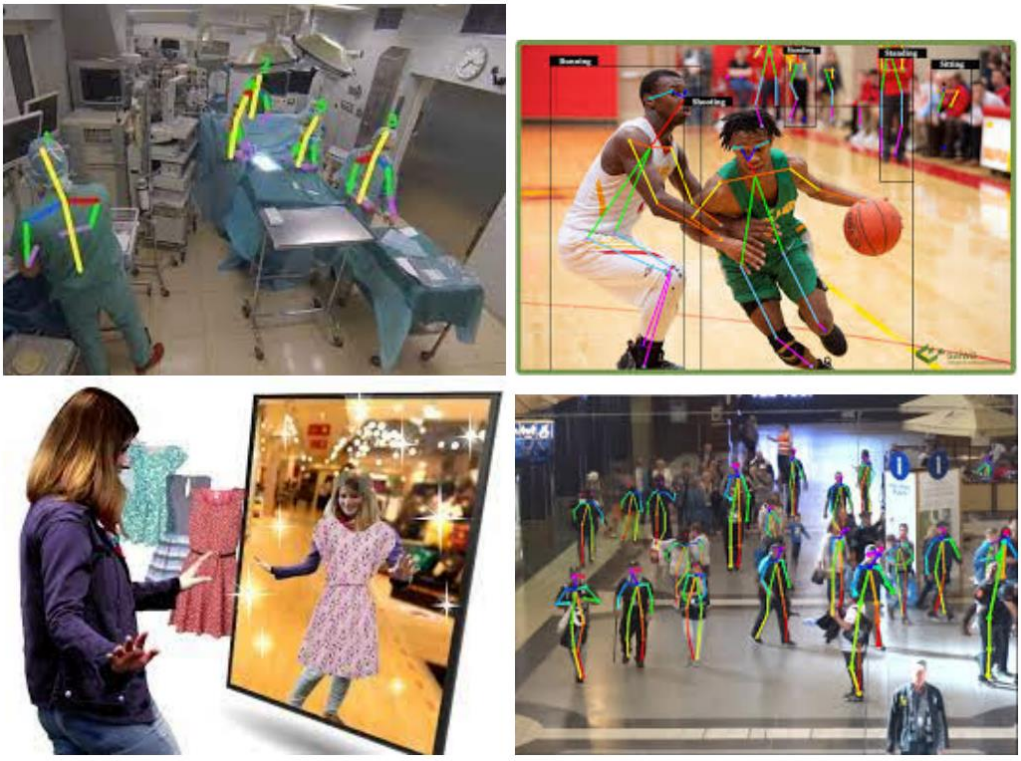

Figure 6.1: Applications (Vasileios Belagiannis 2016)

7 Challenges

- **Depth Ambiguity:** One of the fundamental challenges is the depth ambiguity, where a single 2D pose can correspond to multiple 3D poses. This arises because a camera captures a 3D scene onto a 2D image, leading to a loss of depth information.

- **Occlusion:** In actual life situations, body parts may be completely or partially obscured. Occlusion is the state in which a body portion is obscured from vision, making it difficult to determine the precise locations of body parts that are hidden. When bodily parts overlap or in crowded scenes, this is very common.

- **Scale Variability:** People can appear at various angles to the camera, which can change how big the body seems in the picture. Accurately estimating the absolute size and position of body parts is difficult due to scaling difficulties, especially in 2D-based pose estimation.

- **Multi-Person Pose Estimation:** It is a difficult challenge to estimate the poses of several people in one image or video. Accurately identifying individuals and following their activities can be challenging, particularly in busy environments.

- **Articulation Variability:** The articulations and range of movements of the human body are extensive. For models to manage a wide range of body postures, motions, and limb articulation variations, they must be robust.

- **Human Body Modeling:** One of the main challenges is making realistic models of the human body and its articulations. It is necessary to take into account differences in body sizes and shapes.

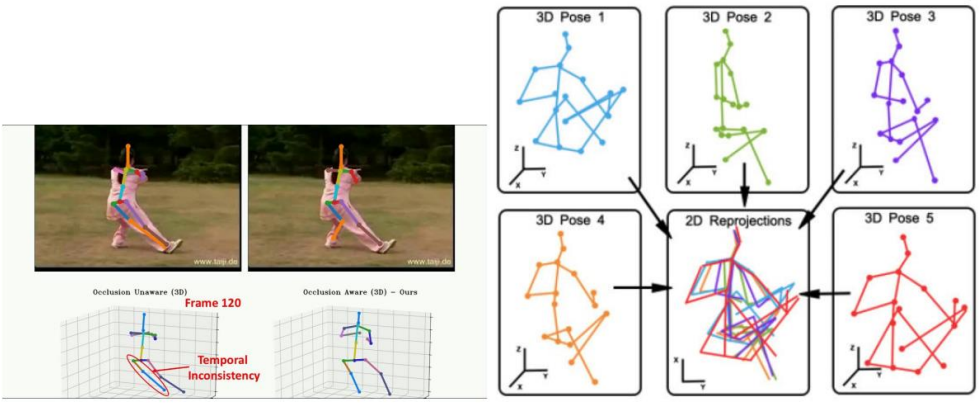

Figure 6.2: Challenges (S. C. Zhang 2022)

8 Conclusion

This work has explored the complex topic of 3D human pose estimation, which has an extensive range of applications in several domains. Although it has been a difficult task to record and analyze the three-dimensional positions of the human body in real-time circumstances, this study's notable advancements suggest that the technology may have revolutionary implications. Our technology, which makes use of 3D human pose estimation, has the potential to transform a variety of industries, including immersive gaming and healthcare diagnostics. Our method has the potential to improve fall warning systems for the elderly, advance gesture-based human computer interaction, and make it possible to create lifelike avatars in virtual environments by correctly detecting human body motions and poses. Although this work is a significant step in the right direction, there is still much work to be done before 3D human pose estimate can be fully utilized.

Considerable progress has been achieved in tackling the problems related to 3D human pose estimation. Our 3D Pose estimation approach, which makes use of machine learning and computer vision techniques, has been applied effectively. This model opens the door for accurate and real-time tracking of human movements with its remarkable accuracy in calculating the positions of different body joints. We have also looked into other uses for this technology, such as fall detection for the elderly, where it has the potential to greatly enhance the security and wellbeing of senior citizens. Although further work is needed to fine-tune and improve the model for wider applications, the findings of this study highlight how 3D human pose estimation has the potential to revolutionize the fields of healthcare, human-computer interaction, and other fields.

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Bilingual Minutes of the Meet Generator

Aarushi Sharan [1], Nandika Rathore [2], Yashveer Tiwari [3] & S. S. Sonawane [4]

[1]Student; Pune Institute of Computer Technology, (CE), Pune, Maharashtra, India, aarushirsharan@gmail.com
[2]Student; Pune Institute of Computer Technology, (CE), Pune, Maharashtra, India, nandikarathore@gmail.com
[3]Student; Pune Institute of Computer Technology, (CE), Pune, Maharashtra, India, yashveertiwari2001@gmail.com
[4]Associate Professor; Pune Institute of Computer Technology, (CE), Pune, Maharashtra, India, sssonawane@pict.edu

Abstract:

A Minutes of Meeting generator plays a pivotal role in addressing critical needs for organizational efficiency and communication. By automating the meticulous process of documenting meeting proceedings, this tool ensures not only accuracy, consistency, and standardization in the minutes but also saves valuable time previously spent on manual transcription and formatting. The generator establishes a clear, standardized format that facilitates easy reference, contributing to a more streamlined and efficient documentation process.

Moreover, the digitized Minutes of the Meeting offer enhanced accessibility, searchability, and the capability to be tagged for categorization, significantly boosting their usability. Beyond these advantages, the Minutes of the Meet generator supports compliance efforts by ensuring that meetings and decisions are documented in alignment with legal or industry standards.

In addition to its role in compliance, the generator facilitates real-time updates and seamless integration with other organizational tools. In essence, a Minutes of Meeting generator proves indispensable for efficient administrative processes, particularly beneficial for large enterprises or teams with frequent meetings, as well as in regulated environments where meticulous documentation is paramount to success.

Keywords: Text Summarization, Speech Recognitions, NLP, Minutes of the Meet, Transcription. **1**

Introduction

Meetings are an essential part of professional life as they help in collaboration, decision-making, and information exchange. However, the process of recording meeting minutes can be time-consuming and challenging. Manual minute-taking can consume resources, introduce inaccuracies, and hamper efficiency. Natural Language Processing (NLP), a subset of artificial intelligence, has emerged as a solution to address this issue. With the advancements in NLP, automated systems, known as NLP minutes of the meeting generators, have revolutionized meeting documentation.

This paper aims to explore the development, capabilities, and implications of NLP meeting generators. It delves into the technologies, applications, and benefits of NLP and analyses the challenges, concerns, and ethical considerations in adopting NLP. The paper fosters a discussion on the role of NLP in business communication.

A solution has been proposed to address the challenge of manual meeting documentation. The proposed solution is technologically driven and automates the Minutes of the Meeting (MoM) process. The solution utilizes various

technologies, including ASR, NER, Sentiment Analysis, and Simulation Algorithms to ensure a comprehensive approach. The solution takes into consideration linguistic and cultural contexts, efficiency, accuracy, as well as ethical and privacy concerns. This approach utilizes the latest developments in natural language processing (NLP) and other relevant technologies to automate the generation of meeting minutes.

The field of Automatic Speech Recognition (ASR) has experienced a significant transformation thanks to the advancements in deep learning, specifically neural networks [1]. Complex feature engineering is no longer necessary for End-to-End ASR systems, like "Listen, Attend, and Spell"[2]. Additionally, the demand for multilingual support is met by Multilingual ASR, as explored in "Massively Multilingual ASR and TTS"[3]. Furthermore, "Listen, Attend and Walk"[4] addresses the need for reliable performance in noisy environments, ensuring robust ASR in challenging conditions.

The field of Named Entity Recognition (NER) has evolved from rule-based approaches to machine learning and deep learning techniques. Recently, transformer-based models such as BERT have shown remarkable performance in NER, as demonstrated in the study "BERT for Named Entity Recognition"[5]. Another area of development is multilingual NER, which aims to extract named entities from various languages. The XLM-R model, introduced in "XLM-R: Multilingual NER with Cross-Lingual Pretraining"[6], is one such model. Additionally, there are domain-specific NER models that cater to specialized domains like biomedical or legal texts. These models are still in development and are continuously being improved.

Sentiment analysis has developed over time, moving from rule-based to machine learning and deep learning methods. With the recent advancements in transformer-based models such as BERT, the accuracy and efficiency of sentiment analysis have significantly improved.[7] Aspect-Based Sentiment Analysis is a specialized technique that focuses on identifying sentiment toward specific aspects of a text [8]. Multilingual Sentiment Analysis is a technique that deals with sentiment analysis across multiple languages. The paper titled "Multilingual Sentiment Analysis with Transformers"[10] explores this topic in detail. There are certain challenges to this sentiment analysis as well. FineGrained Sentiment Analysis: Improving sentiment analysis to recognize fine-grained sentiment categories beyond just positive and negative. Emotion Detection: Advancing sentiment analysis to detect and classify emotions such as joy, anger, sadness, and more. Multimodal Sentiment Analysis: Integrating visual and audio information with text for more comprehensive sentiment analysis. Cross-Domain and Cross-Lingual Sentiment Analysis: Extending sentiment analysis models to work well across different domains and languages.

Simulation algorithms, including Monte Carlo Simulation, Discrete Event Simulation, Agent-Based Modelling, and Machine Learning-driven simulation, have seen significant developments.[9]

Quantum Simulation leverages quantum computers for modelling quantum systems.

Text Rank is a graph-based approach that takes inspiration from Google's PageRank algorithm, which assesses the significance of web pages in search engine results. In the domain of keyword extraction, Text Rank builds a graph representation of the text, where words or phrases are nodes, and the connections between them are edges. The algorithm assigns scores to each node based on the graph structure, where higher scores indicate greater importance. Text Rank has been proven effective in identifying keywords by considering the contextual relationships between

words and phrases in a document. The method is particularly helpful for capturing key terms that are crucial to the overall meaning of the text.

Frank et al. (1999) introduced a supervised algorithm in their paper titled "A Simple Algorithm for Identifying Abbreviation Definitions in Biomedical Text." This approach to keyword extraction relies on machine learning techniques and operates by learning from annotated data. In a supervised setting, the algorithm is trained on a dataset where examples of keywords are labelled, indicating their presence or absence in the text. The model then generalizes from this labelled training data to identify keywords in unseen or new texts.
In the context of the mentioned paper, the algorithm likely involves the use of features derived from the text, such as word frequency, context, or syntactic patterns, to train a machine-learning model. The model learns to recognize patterns associated with the presence of keywords, particularly focusing on abbreviations and their definitions in biomedical texts. This method is beneficial when a reliable labelled dataset is available for training, enabling the algorithm to learn the characteristics of keywords specific to the biomedical domain.

Turney and Littman delved into unsupervised keyword extraction in their work "Measuring Praise and Criticism: Inference of Semantic Orientation from Association."[11] Unlike supervised methods, unsupervised approaches do not rely on labelled training data. Instead, they aim to identify keywords by exploring inherent patterns, relationships, or properties within the text itself.
In the specified paper, Turney and Littman likely used unsupervised techniques based on the semantic orientation of words. Semantic orientation refers to the polarity or sentiment associated with words, and by measuring the associations between words in a corpus, this method infers the semantic orientation of a term. Terms with strong associations are considered potential keywords, as their relationships with other terms contribute to the overall meaning of the text. Unsupervised methods are advantageous in scenarios where obtaining labelled data for training is challenging or impractical, allowing for broader applicability across various domains and types of texts.

Lin introduced the ROUGE metric in the paper titled "ROUGE: A Package for Automatic Evaluation of Summaries."[12] ROUGE is a set of metrics designed for the automatic evaluation of machine-generated summaries. The primary focus of ROUGE is on assessing the quality of summaries based on recall, which measures the ability of the system to capture important information present in the reference summaries.
ROUGE evaluates the overlap between the n-grams (contiguous sequences of n items, usually words or characters) in the machine-generated summary and the reference summary. It includes various measures such as ROUGE-N (unigrams, bigrams, trigrams, etc.), ROUGE-L (longest common subsequence), and ROUGE-W (weighted overlap) to capture different aspects of summary quality. ROUGE has become a standard metric in the field of natural language processing particularly in tasks like keyword extraction and summarization.

Cross-lingual key phrase extraction [13] addresses the challenges associated with extracting keywords from documents that span multiple languages. Cross-lingual key phrase extraction is particularly relevant in scenarios where

documents are available in different languages, and there is a need to identify key terms that convey important information across language barriers. The study likely explores techniques that leverage bilingual dictionaries or other cross-lingual resources to enhance the accuracy of key phrase extraction in a multilingual context.

Guo (2020) proposed "BERT-MEE: Multilingual End-to-End Key Phrase Extraction,"[14] introducing a method that leverages multilingual BERT (Bidirectional Encoder Representations from Transformers) for cross-language key phrase extraction. BERT, a powerful transformer-based model, is known for its contextualized word representations and has been widely adopted in various natural language processing tasks.
In the context of key phrase extraction, BERT-MEE likely extends the capabilities of BERT to handle documents in multiple languages seamlessly. The use of multilingual BERT allows the model to capture contextual information and semantic relationships across diverse languages, enabling more accurate and context-aware key phrase extraction. Multilingual models like BERT-MEE contribute to breaking down language barriers in information extraction tasks, making it possible to obtain meaningful keywords from documents irrespective of the language in which they are written. This advancement is crucial for applications dealing with multilingual content, such as global information retrieval and cross-cultural knowledge discovery.

The collective impact of these technological advancements is poised to reshape communication and information processing in professional settings. The proposed solution not only addresses existing challenges but also sets the stage for a future where automated, intelligent systems play a central role in ensuring efficiency, accuracy, and ethical considerations. As these technologies continue to evolve, the envisioned transformation holds the potential to elevate professional practices, fostering a new era of streamlined, informed, and responsible communication and decisionmaking.

In summary, the exploration of Natural Language Processing (NLP) and its related technologies in this paper reveals a paradigm shift in addressing critical challenges across various domains, including meeting documentation, keyword extraction, sentiment analysis, and simulation. The proposed solution presented for meeting documentation stands out as a testament to the transformative potential of cutting-edge technologies in streamlining and automating traditionally cumbersome processes.

2 Proposed Methods

The system has four main steps to translate and summarize meeting minutes in a source language to a target language. The steps are as follows:

1. Data Collection:

Collect a diverse range of meeting minutes in the source language and their corresponding translations in the target language. Include various meeting types, topics, and domains to ensure dataset diversity.

2. Data Preprocessing:

Clean and preprocess the collected data to remove any irrelevant content, formatting inconsistencies, and noise. Tokenize the text and create aligned bilingual sentence pairs for training.

3. Model Selection:

Use BART (Bidirectional and Auto-Regressive Transformers) as the AI model for translating and summarizing meeting minutes. BART is chosen because of its sequence-to-sequence capabilities and its translation and summarization capabilities.

4. Model Training:

Fine-tune the pre-trained BART AI model using the collected bilingual dataset. Train the model to perform two primary tasks: translation (translate meeting minutes from the source language to the target language) and summarization (generate concise summaries of the meeting minutes in the target language).

2.1 Algorithm:

1. Start
2. Import Bart and Speech Recognition;
3. Listen to the user's speech using the listen() function;
4. Transcribe the speech using the recognize_google() function; 5. Tokenize the text;
6. Generate the summary and then de-tokenize it; 7.

Print the summarized text;

8. Stop.

2.2 Speech to Text:

- Importing the Speech Recognition [15] library in Python.
- Then utilize the imported library to set up the device microphone as the source.
- After that employ the `listen()` function to actively capture and record the speaker's voice through the microphone.
- Then apply the `recognize_google()` function to transcribe the recorded audio into textual format, hence leveraging Google's speech recognition capabilities to convert spoken words into written text accurately.

2.3 Summarization:

- Summarization starts by importing the transformers library in Python, which facilitated access to various natural language processing models and tools.
- Facebook's Bidirectional and Auto-Regressive Transformers as the model for summarization were used for this. This model is known for its effectiveness in capturing contextual information from both directions and generating coherent summaries.

- Tokenization of the entire input speech by leveraging the pre-trained transformer model. Tokenization involves breaking down the input speech into smaller units (tokens) for further processing.
- Later, the selected transformer model generates a concise summary of the tokenized speech. The model's architecture enables it to understand the contextual nuances and key information, ensuring a meaningful summarization.
- Then, the tokens are then de-tokenized in the generated summary, reconstructing the text into a coherent and readable format.
- This de-tokenized output represents the final summarized version of the input speech, capturing the essential information while maintaining readability and coherence.

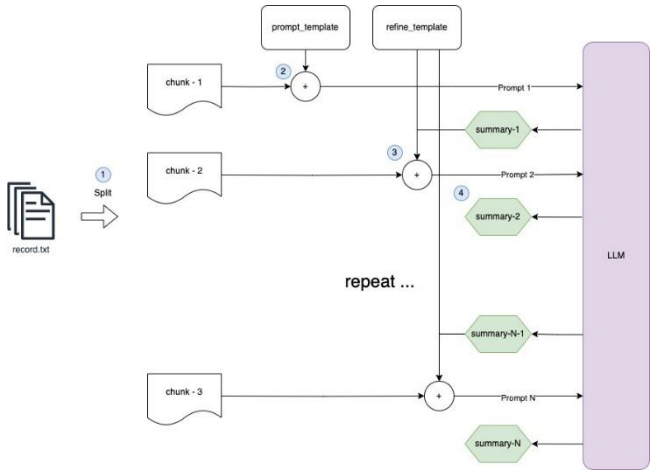

Fig.1: Document Summary Refine Workflow [16]

2.4 BART's architecture [18]:

- BART is built upon the Transformer architecture, which consists of an encoder-decoder framework with self-attention mechanisms.
- Transformers use self-attention mechanisms to weigh the importance of different words in a sequence when processing each word, enabling the model to capture long-range dependencies.
- BART incorporates bidirectional pretraining, which means it is trained to predict both the previous and next words in a sentence. This bidirectional training helps the model capture contextual information from both directions.
- The auto-regressive pretraining aspect involves training the model to generate a target sequence one token at a time, conditioned on the preceding tokens. This prepares the model for tasks like language generation. • BART is pre-trained using a masked language modelling objective, like BERT (Bidirectional Encoder Representations from Transformers). During training, random tokens in the input are masked, and the model is trained to predict these masked tokens.

- After pretraining, BART is fine-tuned for specific tasks using a sequence-to-sequence training setup. This involves using a pair of input and target sequences, where the model is trained to generate the target sequence from the input sequence.
- In the context of text summarization, BART can be fine-tuned using pairs of sources (original text) and target (summary) sequences. The model learns to generate concise and coherent summaries of input texts.

3. Results & Discussion

3.1 Equations [18]

First, the model is pre-trained on tokens "t" looking back to "k" tokens in the past to compute the current token. This is done unsupervised on a vast text corpus to allow the model to "learn the language."

$$L_1(T) = \sum_i \log f_0 P(t_i | t_{i-k}, \dots, t_{i-1}; \theta) \quad (1)$$

Next, to make the model robust on a specific task, it is fine-tuned in a supervised manner to maximize the likelihood of label "y" given feature vectors x1…xn.

$$L_2(C) = \sum_{x,y} \log f_0 P(y | x_1, \dots, x_n) \quad (2)$$

Combining 1 and 2, we get the objective in 3. Lambda represents a learned weight parameter to control the influence of language modeling.

$$L_3(C) = L_2(C) + \lambda L_1(C) \quad (3)$$

3.2 Tables and Figures

Table 1 Evaluation Metrics

Test	Score (0 - 1)
BLEU score	0.209025
ROUGE-1 score	0.507937
ROUGE-2 score	0.287582
ROUGE-L score	0.47619

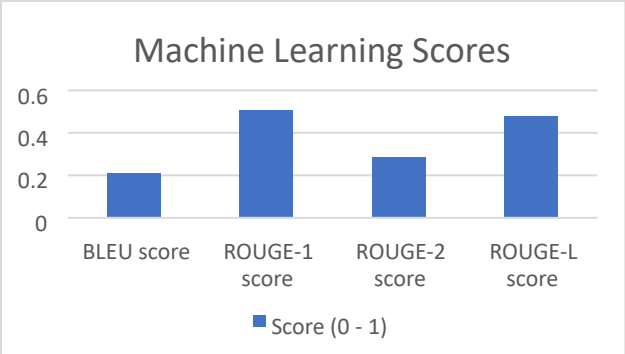

Fig. 2: Chart 1: Histogram of the Evaluation metrics Obtained.

CNN daily mail dataset [17] is used for analysis purposes. Evaluation metrics - BLEU (Bilingual Evaluation Understudy and ROUGE (Recall-Oriented Understudy for Gisting Evaluation) is used for analysis purpose. The analysis is shown in table 1. The Rouge L score indicates a marginally good overlapping score of system summary with reference summary.

4 Conclusion

In summary, the development of a Bilingual Minutes of the Meeting (MoM) generator represents a notable advancement in the domain of natural language processing and meeting management. This innovative tool has the potential to transform the way organizations conduct and document their meetings, particularly in the context of international communication.

While the Bilingual MoM generator shows promise in addressing language barriers and enhancing meeting documentation, it is not without its challenges. Language pair dependencies, accuracy issues, and the handling of cultural nuances pose hurdles that require attention. Additionally, privacy and post-editing concerns remain valid. Looking ahead, there are significant opportunities for improvement and expansion. Multilingual support, improved domain adaptation, and real-time translation hold the promise of enhanced accuracy and user-friendliness. Privacy measures and seamless integration with existing meeting tools are vital for broader adoption.

In an era of globalization, the Bilingual MoM generator stands as a valuable tool for promoting cross-cultural understanding and effective communication in diverse contexts. As it continues to evolve and address its limitations, this technology is poised to be indispensable for organizations navigating the complexities of a globalized world. However, the limitation of the research work is the system's effectiveness heavily depends on language pairs, with less common pairs or those with substantial linguistic differences posing challenges, Capturing Cultural nuances, idiomatic expressions, and humor in the source language can be difficult, potentially affecting output quality, resolving ambiguity in the source text, such as homonyms or polysemy, can be intricate and may result in inaccurate translations or summaries and handling sensitive or confidential information in meeting minutes may raise privacy and security concerns, particularly when using cloud-based translation services. The future scope is to Expand the system to support multiple languages and dialects and enhance its applicability in diverse international contexts, develop techniques for better domain adaptation to handle specialized jargon and terminology in meeting content, and enable real-time translation and summarization during live meetings for instant access to bilingual minutes, develop AI models that can self-assess the quality of translations and summaries and provide feedback for refinement and leveraging the latest advancements in AI models, such as more powerful transformer-based models, to improve translation and summarization quality.

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Towards Addressing Bias and Fairness in Machine Learning

Rudraksh Khandelwal[1], Shyam Deshmukh[2]

[1]Student; Pune Institute of Computer Technology (Department of Information Technology), Pune, Maharashtra, India, rudrakshkhandelwal2912@gmail.com
[2]Assistant Prof; Pune Institute of Computer Technology (Department of Information Technology), Pune, Maharashtra, India, sbdeshmukh@pict.edu

Abstract:

The aim is to unravel the process through which ML models iteratively learn and adapt, consequently enhancing their predictive accuracy. Such an exploration is crucial for a comprehensive understanding of the fundamental principles underpinning ML functionality and its practical applications. The breadth of this analysis extends to an examination of the continuous learning processes within ML models, and the implications these have in various real-world domains, such as healthcare and finance. This analysis probes into the manner in which ML models evolve and adapt over time, laying a foundational basis for both experimental and practical applications. This groundwork is pivotal for delving into the continuous improvement and wider applicability of ML models in diverse scenarios, thus highlighting the criticality of ongoing learning and adaptability in artificial intelligence.

A significant focus of this analysis is on the issue of bias in ML, which is often introduced through the data utilized for training. This bias may reflect existing societal biases or arise from data collection methods that do not represent the full spectrum of diversity. The overlook of diverse data sources or erroneous labeling could result in biased outcomes, underlining the need for meticulous data selection and preprocessing. Upholding fairness in ML transcends technical challenges, aligning technological advancements with societal values. This study contributes towards fostering a more equitable and inclusive future, utilizing AI as a positive force in a globally interconnected landscape. The extensive underrepresentation and misrepresentation of protected groups in training datasets gravely affect the fairness and accuracy of ML algorithms. Addressing these biases effectively requires a holistic strategy, encompassing both quantitative assessments and qualitative human evaluations. The implementation of advanced selection algorithms plays a key role in enhancing the representativeness of training sets, thus promoting fairness and mitigating bias in ML models. Employing strategies such as oversampling marginalized groups and bias-aware data curation is crucial for ensuring equitable outcomes from ML models. These algorithmic adaptations ensure that ML models are not only technically adept but also ethically sound.

Keywords: Machine Learning Fairness, Algorithmic Bias Mitigation, Preprocessing, Training Data Representativeness, Ethical AI, Bias-Aware Algorithms, Data Diversity in ML, Inclusive AI Models.

1. Introduction

The Machine learning (ML) models exhibit a dynamic nature, with an emphasis on data-driven learning and predictive evolution. This investigation aims to demystify how ML models iteratively learn and adapt over time, thereby enhancing predictive accuracy. The scope extends to examining the ongoing learning processes of ML models and their real-world implications in diverse fields, forming the basis of experimental and trial work, from healthcare to finance. Data collection methods that skew representation or existing societal biases are often introduced into ML through training data. The commitment to fairness in ML transcends technical challenges, aligning technological progress with societal values. The pervasive underrepresentation and misrepresentation of protected groups in training datasets significantly compromise the fairness and thereby accuracy of ML algorithms. To effectively address these biases, a comprehensive approach is necessary, integrating both quantitative metrics and qualitative human evaluations. Techniques such as oversampling marginalized groups and bias-aware data curation are instrumental in

achieving equitable model outcomes. These algorithmic adjustments ensure that ML models are not only technically proficient but also ethically sound.
Our proposed approach involves implementing advanced selection algorithms and fairness constraints in model training, focusing on enhancing training set representativeness. The key contribution of this study is the development of a novel framework for assessing and mitigating bias in ML algorithms, utilizing a blend of upsampling, downsampling, and ethical AI principles.

The end result is a significant improvement in the fairness and accuracy of machine learning models, evidenced by more equitable outcomes in diverse application scenarios. This advancement not only enhances the technical efficiency of ML models but also ensures their alignment with ethical and societal standards, paving the way for more responsible AI development.

2. Literature Survey

This research paper embarks on a comprehensive literature survey to understand various facets of machine learning, particularly focusing on challenges and advancements in the field. The survey explores pivotal studies that delve into imbalanced datasets, mislabeling impacts, algorithmic decision-making complexities, and the pursuit of data equity in machine learning algorithms. These studies collectively offer invaluable insights into both the current state and potential future directions of machine learning research. The study "Dynamic learning for imbalanced data" tackles the challenge of imbalanced datasets in machine learning. It introduces a dynamic learning framework that enhances classification performance through iterative decision boundary refinement and feedback from misclassified instances. This approach, incorporating instance weighting, boundary refinement, and active learning, is shown to be effective in real-world applications, outperforming other established methods [1]. "Impact of biased mislabeling on learning with deep networks" explores the implications of mislabeling in extensive datasets on deep learning models. The research identifies that even minimal systematic biases in mislabels can substantially deteriorate model accuracy. Highlighting the importance of accurate labeling, the study introduces strategies like robust training to counter these adversities [2]. Addressing the increasing reliance on algorithmic decision-making, "Overcoming the pitfalls and perils of algorithms" provides a detailed overview of related challenges. It points out how biases and transparency issues can arise, advocating for an integrated approach that combines ethical considerations, rigorous validation, and stakeholder engagement for effective navigation of these challenges [3]. The paper "Testing Machine Learning Algorithms for Balanced Data Usage" underscores the necessity of balanced data usage for fairness in machine learning. It reveals that many algorithms might unintentionally prioritize certain data subsets, leading to skewed outcomes. The study proposes a meticulous testing framework to promote balanced data representation and guide algorithm refinement for fairness [4].

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3. Methods and Techniques used

Primarily methods involved manipulating dataset size and distribution to improve model performance with imbalanced data. Both upsampling and downsampling methods are being used to rectify class imbalance issues. There are several advanced algorithms and methods designed to mitigate bias employed in machine learning models being discussed further.

3.1. **Adversarial Debiasing:** This technique treats the process of debiasing as a game between two competing systems: the predictor and the adversary. The predictor tries to make accurate predictions, and the adversary tries to determine if a prediction is biased. Through their interaction, the predictor learns to make decisions that the adversary cannot predict, thus reducing bias.

3.2. **Distributionally Robust Optimization (DRO):** DRO involves optimizing the model against the worst-case distribution within a certain ambiguity set. The idea is to ensure that the model performs well across a range of potential data distributions, particularly focusing on worst-case scenarios which often involve underrepresented data.
3.3. **Decoupled Classifiers:** Instead of using a single classifier, this method uses separate classifiers for different demographic groups and combines their predictions. This can help tailor the model to specific group characteristics.
3.4. **Reject Option Classification:** This approach gives favorable outcomes to instances near the decision boundary, which is often where discrimination occurs.
3.5. **Fairness Constraints:** Incorporating fairness constraints, such as demographic parity or equal opportunity, directly into the optimization problem when training the model. This makes fairness an explicit goal of the model rather than a post-hoc correction.
3.6. **Upsampling of data:** Upsampling involves increasing the representation of the underrepresented class in a dataset to balance the class distribution. This is typically achieved by duplicating existing samples from the minority class or by generating new synthetic samples using techniques like Synthetic Minority Over-sampling Technique (SMOTE). The goal is to provide the model with enough data from the minority class to learn from, thereby reducing the model's bias towards the majority class and improving its predictive performance on underrepresented data.
3.7. **Downsampling of data:** Downsampling is the process of reducing the size of the overrepresented (majority) class in a dataset to match that of the minority class. This is usually done by randomly removing samples from the majority class until the class distribution is more evenly balanced. Downsampling helps in mitigating the model's bias towards the majority class by ensuring that it does not get overly trained on more prevalent data, promoting a more balanced learning process and fairer outcomes. However, care must be taken to avoid significant loss of valuable information from the majority class.

The advantages of upsampling and downsampling can be summarized as follows:

- **Improved Model Performance:** By balancing class distribution, these methods help prevent the model from becoming biased towards the majority class, leading to more accurate and fair predictions across classes.
- **Increased Generalizability:** Balanced datasets typically result in models that generalize better to unseen data, as they are not overfitted to the majority class.
- **Enhanced Fairness:** These techniques directly address fairness in data representation, ensuring that the model has an adequate opportunity to learn from all classes.
- **Flexibility in Application:** Upsampling and downsampling can be applied to virtually any classification algorithm, making them widely usable and easy to integrate into existing pipelines.
- **Simplicity and Accessibility:** Both methods are straightforward to implement with existing libraries and tools, making them accessible to practitioners with varying levels of expertise.

The selection of upsampling and downsampling as mitigation strategies is often predicated on their ability to straightforwardly address the imbalance issue, which is a common source of bias in ML. They can be particularly advantageous in situations where collecting more data is not feasible due to constraints such as time, budget, or availability. Upsampling is especially beneficial when the amount of available data is limited. By creating additional synthetic examples, it allows the model to learn from a richer set of data points. On the other hand, downsampling can be useful to prevent computationally expensive models from becoming overwhelmed with data, or when the data collection process has inadvertently introduced too many examples of a prevalent class.

Upsampling Techniques: Upsampling techniques were implemented to augment the representation of minority classes, creating a more balanced dataset. The strategies included:

1. **Performance-Based Upsampling:** Enhancing poorly performing classes by adding more instances.
2. **Adaptive Upsampling:** Dynamically adjusting upsampling based on real-time model performance.
3. **Importance-Based Upsampling:** Increasing the weight of minority classes.

While upsampling was found to enhance accuracy and fairness, it also introduced challenges such as potential overfitting and increased noise within the dataset.

Downsampling Techniques: In parallel, downsampling techniques were applied to reduce the overrepresentation of majority classes. These techniques included:

1. **Importance-Based Downsampling:** Focusing on majority classes by assigning them greater weights.
2. **Performance-Based Downsampling:** Adjusting class representation to prevent overfitting in well-performing classes.
3. **Adaptive Downsampling:** Dynamically modifying downsampling according to real-time model performance.

Downsampling was observed to improve model generalization and fairness, but it also posed the risk of losing vital information and neglecting important patterns in majority classes.

This structured approach facilitated a comprehensive analysis of managing imbalanced datasets in machine learning. It provided valuable insights and methodologies, enabling replication and further exploration by new researchers in the field. Both established and novel methods were articulated clearly, adhering to proper citation practices for established approaches and offering detailed descriptions for novel techniques to ensure reproducibility. To validate the findings, statistical parameters, performance evaluation metrics, and test results were meticulously documented.

In conclusion, while upsampling and downsampling are powerful techniques for mitigating bias due to imbalanced datasets, they should be chosen with consideration of the specific context and in combination with other methods for the best outcome. When implemented correctly, they contribute significantly to the development of fair and robust ML models. Building upon the foundational understanding of the necessity of balancing datasets in machine learning, this research further delves into specific upsampling and downsampling strategies.

4. Results& Discussion

The research underscored the effectiveness of two primary sampling techniques: upsampling and downsampling, in addressing class imbalances within datasets. These techniques are crucial in machine learning models, particularly for datasets with disproportionate class distributions. Upsampling significantly improved minority class representation, which led to enhanced fairness in model predictions. Downsampling, by reducing the samples of the majority class, contributed to better generalization of the model.

4.1. Results of Upsampling and Downsampling:

In the case of downsampling, where class 0 contains 10 records and class 1 comprises 100 records, the number of records in class 1 is reduced to match that of class 0. This process involves randomly selecting 10 records from class 1, leading to a balanced dataset with an equal number of records in each class. However, this method may result in the loss of valuable data.

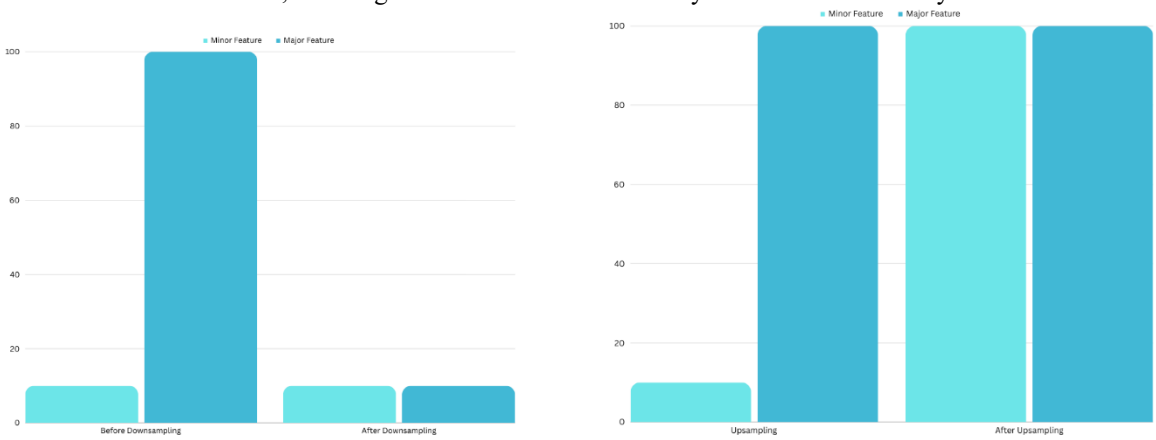
Conversely, in upsampling, the number of records in class 0 is increased to equal that of class 1. This is achieved by duplicating records in class 0, creating additional copies until the count reaches 100, matching class 1. This approach,

while balancing the dataset, can potentially lead to overfitting, as the model is exposed repeatedly to the same instances from class 0.

To avoid overfitting in upsampling, techniques like adding noise to the duplicated data, using more sophisticated data generation methods like SMOTE (Synthetic Minority Over-sampling Technique), or employing robust validation methods like cross-validation can be used.

Real-life examples where these methods are applied include:

1. **Medical Diagnostics:** In datasets where instances of a certain disease are rare, upsampling can help balance the dataset, ensuring the model doesn't ignore these critical but infrequent cases.
2. **Fraud Detection:** Financial institutions often deal with highly imbalanced datasets where fraudulent transactions are much less common than legitimate ones. Downsampling the normal transactions can make the dataset more balanced, allowing the model to learn to identify fraud more effectively.



Down-Sampling Graphical Representation Up-Sampling Graphical Representation

Fig. 1: Down-Sampling & Up-Sampling

Table 1: Detail analysis of sampling

Initial class distribution	Before Sampling Techniques used	After Up-sampling	After Down-sampling	Analysis
Class 0 samples	10	100	10	This adjustment in class distribution demonstrates the technique's efficacy in balancing classes.
Class 1 samples	100	100	10	The reduced sample size of the majority class helps in avoiding model bias towards the majority class.

4.2. Comparative Analysis

- A comparative analysis of both techniques revealed that while both upsampling and downsampling effectively address class imbalances, their impact varies based on the initial dataset configuration and model architecture.
- This comparison underscores the importance of selecting an appropriate method tailored to the specific dataset characteristics.

- These findings have significant implications for developing fairer and more unbiased machine learning models, particularly in sensitive applications like healthcare and criminal justice.

Future research could explore hybrid methods combining both upsampling and downsampling for more complex and varied datasets.

4.3. **Specific Focus on Upsampling and Downsampling:**

Deliberate scrutiny was given to the selection of upsampling and downsampling methods amidst the plethora of de-biasing strategies. These methods were identified as particularly effective for the datasets and contexts within this study, offering a pragmatic balance between improving representation and maintaining data integrity. The choice was predicated on their direct approach to countering class imbalances, a prevalent source of bias, and the compelling need for methodologies that could be swiftly implemented within the constraints of time, resources, and data availability.

4.4. **Case Study : Mitigating Gender Bias in Candidate Selection**

Introduction:

This case study outlines the methodology and outcomes of addressing gender bias within a candidate selection dataset. Initially, the data showed a notable imbalance favoring male candidates. The journey of a particular female candidate, who was not initially shortlisted, is used as a focal point to demonstrate the effects of eliminating such bias.

Initial Data Analysis

The dataset under analysis comprises a total of 1000 entries, each representing a candidate considered for shortlisting. It includes the following columns:

Candidate ID: A unique identifier for each candidate.

Gender: The gender of the candidate, categorized as either 'Male' or 'Female'.

Years Of Experience: The number of years of experience each candidate possesses.

Skill Score: A numerical score representing the skill level of the candidate, on a scale.

Education Level: The highest level of education attained by the candidate, such as 'Bachelor', 'Master', or 'PhD'.

Selected: A boolean value indicating whether the candidate was initially selected or not.

The dataset provides a comprehensive view of each candidate's professional profile, encompassing their gender, experience, skills, and educational background. This data is instrumental in assessing the presence of any bias in the shortlisting process, particularly gender bias.

An initial analysis revealed a skewed gender distribution:
Male Candidates: 709
Female Candidates: 291
A bar chart visualized this disparity:

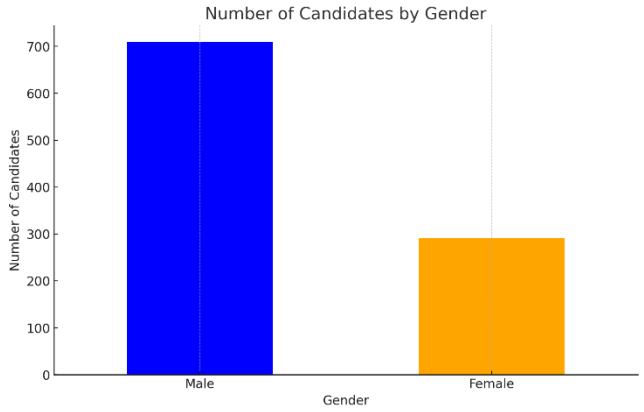


Fig. 2: Bias Removal via Upsampling

To address this imbalance, upsampling of the minority class (female candidates) was performed. The upsampling code:

```
from sklearn.utils import resample

df_majority = data[data.Gender == 'Male']
df_minority = data[data.Gender == 'Female']

# Upsample minority class
df_minority_upsampled = resample(df_minority,
                                 replace=True,
                                 n_samples=df_majority.shape[0],
                                 random_state=123)

df_upsampled = pd.concat([df_majority, df_minority_upsampled])
```

This approach resulted in an equal number of male and female candidates, as shown in the updated bar chart:

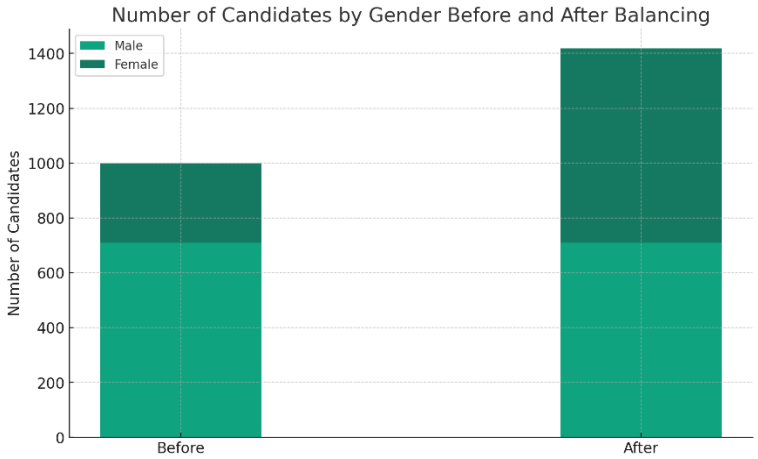


Fig. 3: Machine Learning Model for Shortlisting

A logistic regression model was implemented to predict shortlisting status. Key features included gender, years of experience, skill score, and education level. The model's accuracy was 47%, with room for improvement.

Model code:

```
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report, accuracy_score
from sklearn.preprocessing import LabelEncoder

# Encoding and model training omitted for brevity

model = LogisticRegression()
model.fit(X_train, y_train)
```

Case Study: Female Candidate (ID: 613)
Originally, the candidate with the following profile was not shortlisted:

Years of Experience: 15
Skill Score: ~0.749
Education Level: PhD
In the balanced dataset, applying the same selection criteria led to the candidate being shortlisted, demonstrating the impact of bias removal.

Related Inference

The exercise highlighted the significance of addressing biases in datasets. Through thoughtful data processing and analysis, equitable representation and decision-making can be achieved, leading to fairer outcomes. The change in the shortlisting status of the female candidate underscores the real-world implications of such biases and their rectification.

4.5. Modern Techniques to overcome bias

- **Generative Adversarial Networks (GANs) for Data Augmentation:** GANs are being explored for generating synthetic data that can supplement imbalanced datasets. By training two neural networks simultaneously (a generator and a discriminator), GANs can create new, synthetic instances of under-represented classes, improving model performance on these classes.[8]
- **Meta-learning for Imbalanced Datasets:** Meta-learning, or learning to learn, involves training a model on a variety of tasks so that it can quickly adapt to new tasks. This method is being explored to better handle imbalanced datasets by enabling models to learn more effectively from limited examples in under-represented classes.[9]
- **Transfer Learning with Imbalance Consideration:** Transfer learning involves using knowledge gained while solving one problem and applying it to a different but related problem. Recent research is focusing on adapting transfer learning techniques to be more sensitive to class imbalances, allowing pre-trained models to be fine-tuned on imbalanced datasets more effectively.[10]
- **Cluster-Based Oversampling:** This technique involves clustering the minority class and then oversampling each cluster separately. By creating synthetic samples within these clusters, the method ensures a more nuanced approach to generating new data, maintaining the intrinsic structure of the minority class.[11]

- **Neighborhood Cleaning Rule:** This is an undersampling technique that uses a nearest neighbor rule to identify and remove instances from the majority class that are misclassified as belonging to the minority class. It helps in refining the decision boundaries around the minority class instances.[12]

5. Conclusion

The investigation conducted here addresses the crucial issue of bias in machine learning algorithms, emphasizing the promotion of fairness and the prevention of discriminatory outcomes. By applying a range of de-biasing algorithms and methods, this study contributes to improving unbiased decision-making in various fields, including finance, healthcare, criminal justice, and recruitment. The findings demonstrate a significant improvement in the fairness of machine learning models, proving the effectiveness of the implemented techniques. Compared to existing models, the strategies discussed here display enhanced capability in reducing bias. However, it is recognized that the degree of improvement varies among different sectors. This variation is linked to the unique characteristics of each domain's data and the complex nature of bias within these contexts.

5.1. Addressing Limitations

The research presented does encounter limitations, primarily stemming from data quality and representativeness. The potential for biased or incomplete data necessitates ongoing vigilance and the periodic refinement of datasets. Furthermore, the intricate challenge of defining and operationalizing fairness cannot be understated and remains an area for future exploration.

5.2. Suggestions for Future Research

The path forward necessitates further refinement of de-biasing algorithms, with an emphasis on real-time adaptability to shifting data landscapes. There is also a pressing need for heightened awareness and education regarding the nuances of bias in machine learning, extending through the academic, industrial, and regulatory spheres. Future research should pivot towards devising advanced detection mechanisms for bias, corrective measures for evolving datasets, and a deeper ethical discourse on the role of AI in decision-making.

In summation, this study contributes to the ongoing pursuit of equity in technological applications, presenting a stepping stone towards the broader goal of equitable machine learning practices. The pursuit of fairness is a continual process, demanding concerted efforts in innovation, education, and governance. The aspiration for a technologically equitable future remains a dynamic and collective endeavor, calling for persistent engagement across the spectrum of research, application, and policy formulation.

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Affordable Vehicle Tracking System

Kaushik Shroff [1]

[1]SCTR's Pune Institute of Computer Technology (Electronics and Telecommunication), Pune, Maharashtra, India, e2k20103855@ms.pict.edu

Abstract:

In this research, a low-cost automobile safety and tracking system that transmits real-time latitude and longitude coordinates to a pre-designated smartphone is proposed. It integrates Global Positioning System and Global System for Mobile Communications technologies with a microprocessor in order to function as the primary computing device for the transmission of data, analysis, and gathering.

The fundamental module of this system efficiently communicates location-related information to a designated smartphone after receiving satellite signals for precise geographic positioning. Since its components are cost-effective, its pricing offers sophisticated tracking features without breaking the bank.

It enables dependable, inexpensive automobile asset surveillance, which makes it suitable for both individuals and small enterprises. Tracking in real-time makes it achievable to respond quickly to theft or unauthorized use. The system's straightforward layout makes system implementation and administration simpler for individuals with only limited technical know-how.

This system delivers a simplified, affordable solution for real-time automotive tracking using the aforementioned technologies, enhancing asset safety and accessibility. It accomplishes this by bridging the gap between modern monitoring technology and budgetary restrictions.

Keywords: Global Positioning System (GPS), Global System for Mobile Communication (GSM), General Packet Radio Service (GPRS).

1. Introduction.

The design and implementation of a vehicle tracking system based on GPS and GSM technology is covered in this paper. This system is an embedded solution that uses a GPS receiver to continuously track the location of a moving vehicle and a GSM modem to send the location data to a distant location. The paper includes an overview of the system's hardware and software components, such as the GSM modem, GPS receiver, and microcontroller, as well as the communication protocol that's employed within them. The methods for testing and assessing the system's performance, including the dependability of the GSM communication link and the precision of the GPS data, is also covered in the paper [1].

The suggested approaches provide an efficient and inexpensive method to track a car's location using GPS and GSM technology. The system utilizes an Arduino UNO and a smartphone to manage the GSM module and GPS receiver, allowing SMS updates of the vehicle's location every minute. The user can continuously track the progress of the car and predict the arrival time and distance to a certain destination via an LCD and Google Maps that displays the positions. All things considered, this car monitoring system provides a dependable and practical real-time tracking solution [4].

The GPS module periodically captures the geographic coordinates of the automobile, while the GSM module uses a wireless communication network to send this data, along with other vehicle data, to a distant server or database. In order to determine the vehicle's position on Earth, the GPS module makes use of an ensemble of satellites in orbit. The position of the car is determined by the GPS receiver within the vehicle by receiving signals from a minimum of four GPS satellites [2].

The GSM module, on the other hand, connects remotely to the remote server or database over a cellular network. Through messages sent via SMS or other communication protocols, the module communicates the GPS data to the server along with other data such as vehicle speed, direction, and status. This enables the user to access the vehicle's current location information from any location in the globe with an internet connection [2][3].

The benefits of this present system include accurate location and immediate tracking, increased security measures. Better fleet management: Fleet managers can cut fuel expenses, design better routes, and optimize fleet operations with the use of vehicle tracking technologies. Lower maintenance expenses: By keeping an eye on the state of the car and spotting problems early, vehicle tracking systems can help keep maintenance expenses down [5].

However, the limitations of the current systems tend to be: Cost - Vehicle tracking systems based on GPS and GSM can be costly to set up and maintain, particularly for smaller companies or private users. Power consumption: Over time, the constant power supply needed for GPS and GSM-based devices may deplete the vehicle's battery. Privacy concerns: Some people might be worried about the privacy consequences of having their car's location traced and observed continuously. Data management and storage: It can be challenging to handle and store the massive volumes of data generated by GPS and GSM-based devices. Both people and companies with significant fleets of automobiles may find this to be an issue [5].

Three important components are examined while considering potential improvements to the current system. First, it is predicted that the possibility of integrating with various sensors, such as temperature meters, fuel level indicators, or speed sensors, will provide additional information for improved fleet management and vehicle maintenance. Second, integrating AI technology might provide the system the ability to learn from collected data, which would enable real-time traffic insights, predictive maintenance, and optimal routing. Last but not least, integrating blockchain technology presents itself as a viable option for safe, unchangeable data storage, improving system dependability and data integrity in general.

2. Proposed Methods.

2.1.1. Block Diagram

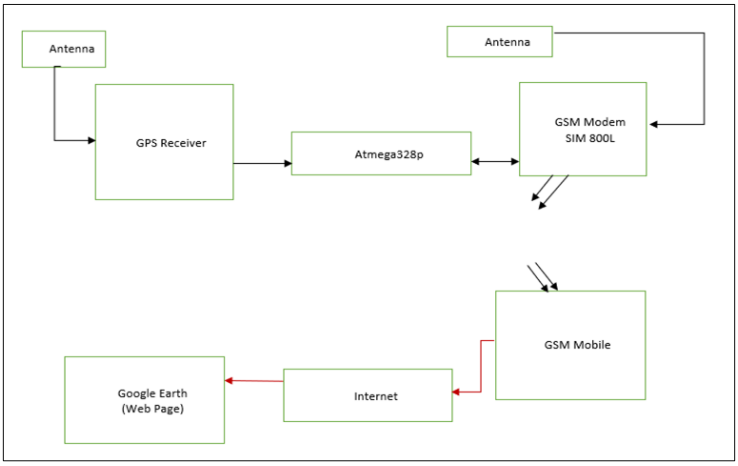

Figure 1: Block Diagram

2.1.2. Technical Approach

1. Research included a review of several vehicle monitoring systems on the market as well as an investigation of the underlying technologies of each, including thorough examinations of GPS and GSM technology to understand its capabilities and constraints.
2. Based on the research findings, a GPS receiver, an ATMega microcontroller, and a GSM modem were used to construct a system. The right parts were chosen after the necessary hardware and software requirements were established.

3. Proteus Simulation Software was used to simulate the system, and AVR Studio 7 IDE was used for system development. The ATMega microcontroller was programmed using embedded C code, while SMS messaging operations on the GSM modem were programmed using SIM800L GSM Modem AT Commands.
4. The technology was tested to ensure that it could track the vehicle's location precisely and report it quickly when needed. Furthermore, in order to verify the functionality of remote system control, the SMS command capability was tried.
5. Refinement methods were started after testing in order to improve the accuracy, dependability, and user-friendliness of the system based on the results that were received. When it was thought necessary, changes were made to the hardware and programming.

3. Results & Discussion

3.1. Results

3.1.1. Simulation Result

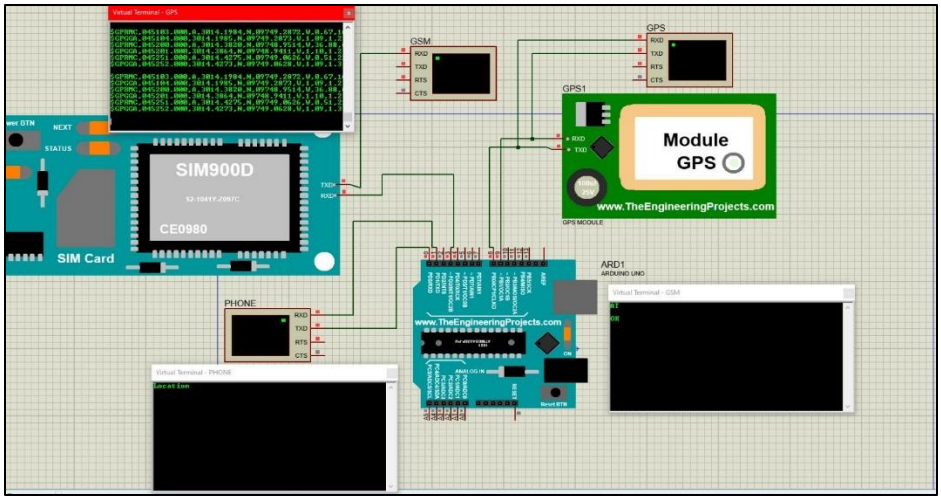

Figure 2: Simulation Result

3.1.2. Implementation on Breadboard

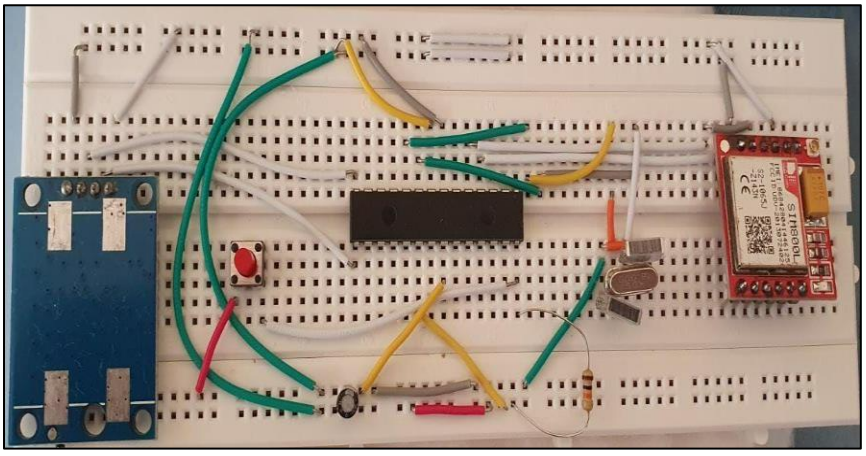

Figure 3: Breadboard Implementation

3.1.3. PCB Design

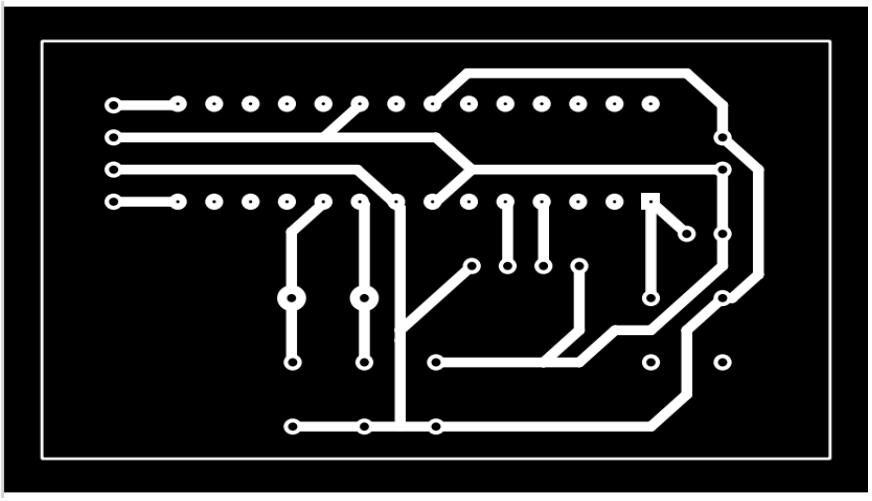

Figure 4: PCB Design

3.1.4. Working prototype

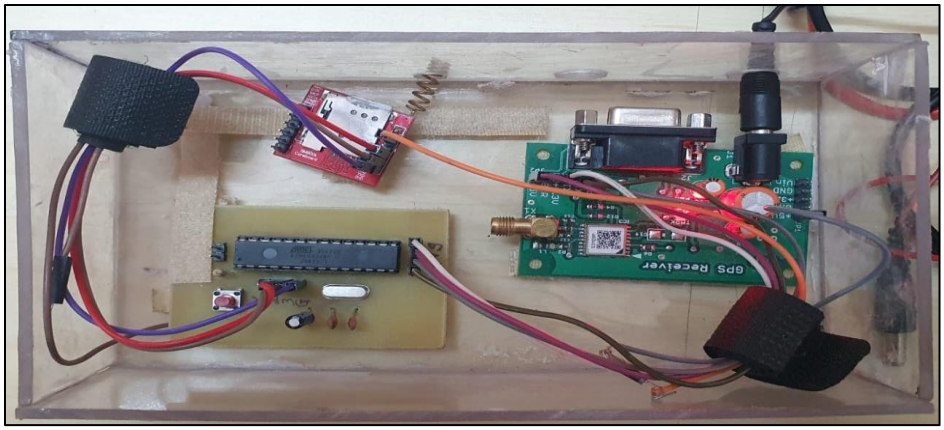

Figure 5: Prototype

3.1.5. Observed outputs

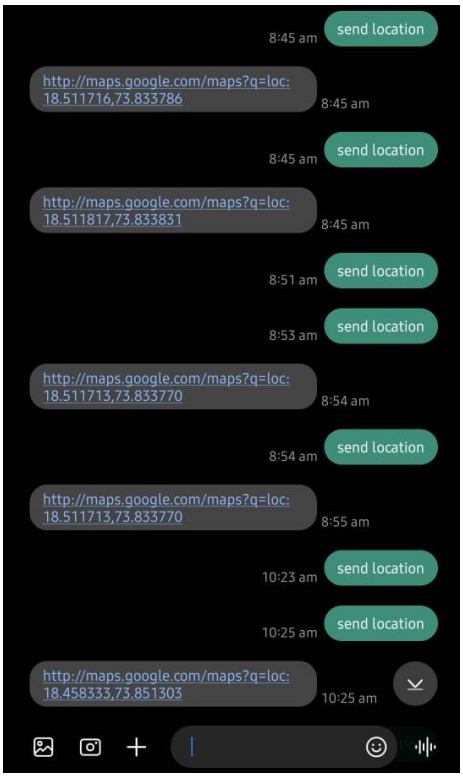

Figure 6: Requested Message

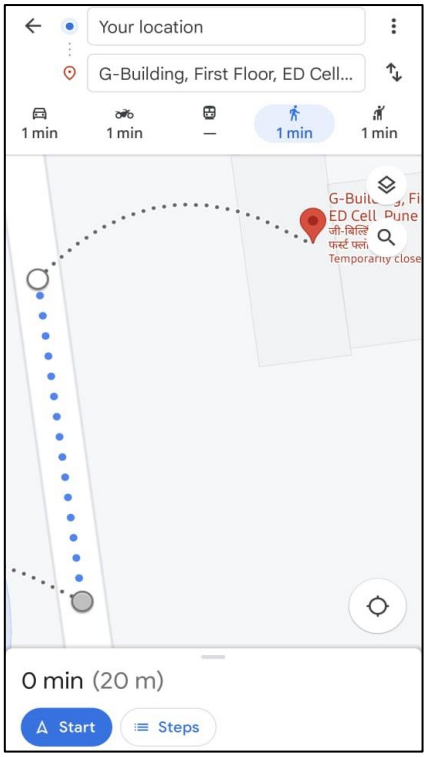

Figure 7: Received Location

3.2. Tables

Table 1: Simulation Observation.

Sr. No.	Test	Observation
1.	Co-ordinates	The GPS modem will continuously give the data i.e. the latitude and longitude indicating the position of the vehicle
2.	GSM Modem	It sends the position (Latitude and Longitude) of the vehicle from a remote place.
3.	Input to the system	Sending a message to the GSM receiver. Ex:- "Send Location"
4.	System Response	Google map link is sent on mobile by SIM800L
5.	System Stability	The system remains stable and responsive even with variations in input voltage, indicating that it is robust andreliable.

Table 2: Testing, Debugging Observations.

Test	Expected Outcome	Actual Outcome	Action Taken	Results
Microcontroller operation	Armega328 performs programmed functions correctly, sending and receiving signals.	The microcontroller does not respond to input or sends incorrect signals.	Verfied programming code, tested microcontroller.	Programming error found and corrected. Microcontroller now responds correctly to inputs.
GPS operation.	Continuous sending of co-ordinates	Continuous sending of co-ordinates between 20m to 500m with accuracy.	Proper exposure of the antenna to the sky and testing it in open-air conditions.	Consistent accuracy upto 20m.
System stability	The system remains stable and responsive even with variations in input signal.	System crashes or behaves unpredictably under certain conditions.	Tested system under different at remote places.	Quick response at the receiver side by sending a Google map link.

3.3. Discussion

- The work's main findings and ramifications for a low-cost vehicle tracking system can be summed up in this statement. The demonstrated tracking method is a viable and effective way to track cars, in accordance with the project's findings. A broad spectrum of users, including individuals and small businesses, are able to utilize the system as it can provide precise GPS coordinates at a low cost. The system's affordability is achieved via the use of off-the-shelf components and a layout that minimizes the need for expensive hardware. This makes the system a more economical resolution for tracking vehicles in contrast to alternative solutions.

- The study additionally emphasizes how the proposed tracking system will impact vehicle safety and security in significant manners. The systems can lessen the possibility of auto theft and raise the likelihood of retrieval in the instance that it happens through providing exact geographic information. Moreover, the system has the capacity to track the automobile's driving style, which can improve security and reduce the potential of accidents.

- The analysis did concede, though, that additional research and development may be necessary to optimize the system for different automobile makes as well as operational environments. To ensure the precision and dependability of the entire system, it has to be evaluated in diverse geographical locations and climatic conditions. It may be necessary to alter the system to fit various automotive types and their particular requirements.

- Overall, the study's conclusions indicate that the proposed affordable automobile tracking system has an extensive amount of potential as an inexpensive and reliable vehicle tracking solution, with significant implications for the security and safety of automobiles.

4. Conclusion

GSM and GPS technologies have been utilized for the development and design of a relatively economical real-time automobile tracking system. Via an app, the system in question provides continuous automobile monitoring. Recognizing the growing demand for automotive security, a thorough analysis and study was carried out on the present condition of current tracking technologies. After identifying a few drawbacks, a model that would enhance the level of accuracy and value for money of vehicle surveillance systems was put forth. Upon the prototype's assembly and testing, accurate latitude and longitude coordinates for the motor vehicle can be consistently detected, with an accuracy of up to 20 meters.

Features:-

1. Real-time Tracking.
2. Geofencing.
3. Affordable and portable.

5. Future Scope

1. Prototype can more cost-effective by adding advanced features like an anti-theft system into the ignition and handy by reducing the volume occupied by the device.

2. Blockchain technology can be used to store the tracking information on the decentralized system to maintain privacy and immutability from 3rd parties.

3. It can be a self-powering device and a one-time investment for a customer also reduces maintenance costs for the user.

4. Speed Alert for vehicles.

6. Acknowledgement

I would like to express my sincere gratitude to all the people who have supported us in the completion of this project. Firstly, I would like to thank our professors for their guidance, support, and valuable feedback throughout the project. Their expertise and insights have been invaluable, and I am grateful for their encouragement and advice.

In addition, I want to convey appreciation to Pune Institute of Computer Technology for providing me the resources and equipment that that I required to complete the project. Their help and backing have been crucial to the project's success.

I find no words to express how much my parents have supported, and encouraged me to pursue this endeavour. My thanks and appreciation go out to my project's teammates and others who volunteered their skills to assist us. With thanks to all.

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Analysis And Modelling of Universal Buffer Circuit for Guitar Pedals

Malhar Choure [1], Ruchir Nagar [2]

[1]SCTR's Pune Institute of Computer Technology ,Department of Electronics & Telecommunication Engineering, Pune, Maharashtra, India, E2K20104114@ms.pict.edu

[2]SCTR's Pune Institute of Computer Technology ,Department of Electronics & Telecommunication Engineering, Pune, Maharashtra, India, E2K20104105@ms.pict.edu

Abstract:

This paper attempts to explain what a guitar pedal is along with its working. It also sheds light on the various pedal types and later dives into the functioning and implementation of a universal buffer circuit using discrete off-the-shelf components along with its block diagram, component description, working of each block and a proposed model. At the end, the results obtained from the study would be used to draw conclusions from the studies carried out in this paper and suggest a future scope for such do-it-yourself modular pedals.

Keywords: Guitar Pedal, Effect, Echo Effect, Discrete Off-The-Shelf Components, Op-Amps (Operational Amplifiers)

1 Introduction

In the musical industry, string-based instruments like guitars are crucial parts of any symphony. Earlier, guitars used to rely on echo chambers to produce musical notes, but since the inception of electric guitars, they no longer solely rely on resonance, but use an external amplifier to deliver the desired sound. Inclusion of electronics in a guitar opened a new dimension of music where effects can directly be added to the guitar's output. These devices are called guitar pedals & there is a wide variety of effects which these devices can impart to the sound.

Guitar effect guitar pedals have been used in music for decades, and are popular among guitarists, bassists, and other musicians. They work by capturing an incoming audio signal, adding certain effects to the received sound & mixing it back in the output.

A basic block diagram of any guitar pedal follows the below mentioned structure as seen in [1].

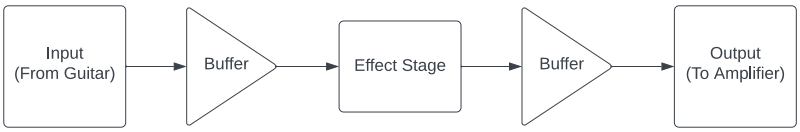

Fig. 1 Basic Guitar Effect Pedal Block Diagram [1].

The basic block diagram consists of five stages:

- The first stage consists of getting signal input from the guitar by using pickups.
- This is followed by a buffer stage, which may amplify the signal or define signal limits with respect to frequency or amplitude alongside providing isolation.

- Singal from the input buffer is sent to the effect block where the desired effect characteristics are imparted to the signal.
- After the effect stage, another buffer block is used to again shape the signal in terms of frequency and amplitude. This block also isolates the amplifier block from the effect circuitry.
- The shaped signal is then sent to an amplifier which amplifies it and makes the sound audible.

In terms of the distinct types of guitar pedals, they are classified into four categories [2]:

- Dynamic Effect : Shapes the volume of tones.
- Time-based Effect : Changes the playback time of tone.
- Frequency-based Effect : Alters specific frequencies of tone.
- Modulation Effect : Use LFO (Low Frequency Oscillators) to vary shape of sound.
- Modelling Effect : Use signal-processing power to digitally model the electronic, mechanical, and magnetic characteristics inherent to an instrument to create completely new sounds. It employs both time-based and frequency-based effects.

Based on the above-mentioned effect types, conventional pedals for effects like Acoustic Simulator, Chorus, Compression/Sustain, Delay/Distortion, Fuzzy can be classified into separate groups.

While studying such pedals [6-9], it was realized that guitar pedals are not manufactured in India, and the cost of purchasing a guitar pedal was quite high due to the same reason. Alongside this, each pedal only imparts a single effect, and one needs to purchase multiple pedals for individual effect. To address this issue, this paper aims to describe a model for a modular guitar pedal which can be used to impart different effects, which would use off-the-shelf components and be economic when compared to its professional counterparts and offer satisfactory performance at the same time.

This model plans to implement the power supply, buffer stage ,a true bypass switch & a dry signal cutoff switch, all of which are common components of any guitar pedal [6].
The flexible nature of this model would also allow enthusiasts to modify the specifications to tune to sound characteristics based on the individual's liking.

2 Proposed Methods

Based on the research carried out in this paper, it was clear that all pedals require the following components :

- Power Supply Module
- Input & Output Buffer Circuity.
- Path to bypass effect circuitry.

This model allows the user to keep the minimum required circuitry common for all effects and just vary the effect circuit to change the output effect.

A generic circuit diagram for the power & buffer block is as mentioned below based on reference from [3].

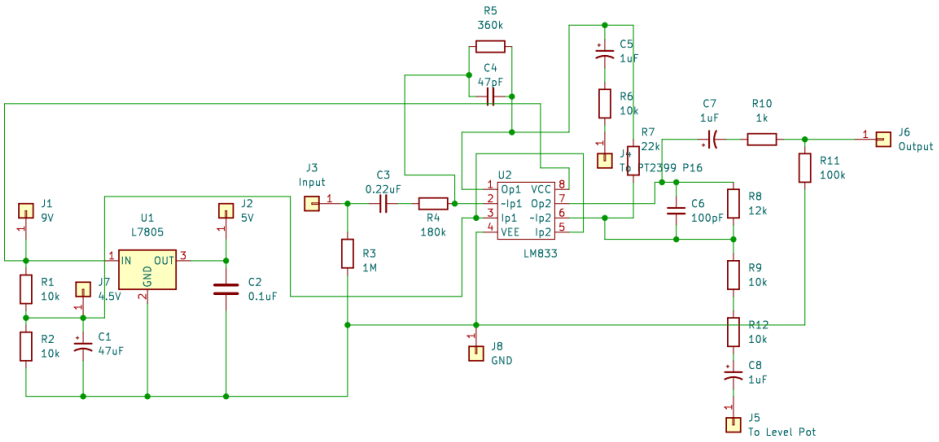

Fig. 2 Schematic Diagram for Basic Power Supply & Buffer Circuit.

Figure 2 depicts the schematic design which consists of a power supply module based around 7805 5V Power regulator module and the buffer block using LM833.

Any pedal requires 3 voltage levels to function namely +9V, +4.5V, and 5V. To make the design compatible with commercial pedals, a +9V 6LR61/006P battery is used to power the circuit, which inherently provides +9V. Since the circuit draws around 8mA of current, this battery can power the circuit for a significant amount of time. +4.5V can be obtained by a simple voltage divider configuration while the +5V voltage level is obtained from the regulator [13,14].

For the buffer circuit, IC LM833 is used as it has 2 high slew rate Op-Amps which can handle voltage swing of up to ±18V. A comparison table for equivalent circuits has been depicted below.

Table 1 IC Comparison for Buffer Circuit.

Parameter	**LM833**	**NE5532**	**TL072**
IC Type	Op-Amp	Op-Amp	Op-Amp
V_{CEO} (V)	±18 V	±15 V	±30 V
Package	DIP/SOIC	DIP/SOIC	DIP/SOIC
Type	Dual	Dual	Dual
Slew Rate at Unity Gain	7 V/µS	9 V/µS	20 V/ µS
Gain Bandwidth Product	10 MHz	100 kHz	5.25 MHz
Thermal Specifications	-40 to 85°C	-40 to 85°C	0 to 70°C

Table 1 shows a comparative analysis of the various compatible & widely used Op-Amps. Here, LM833 offers a high enough slew rate along with the best Gain bandwidth product with the desired operational range for voltage swing. Moreover, the main reason for choosing LM833 was its cost and availability.

In Figure 2, the first Op-Amp of LM833 acts as a high pass filter having cutoff of around 8 Hz and is used in as a differential amplifier having gain factor as 2.

Cutoff frequency can be calculated by using formula 1 [6,11,13-14].

$$f_{high-pass} = \frac{1}{2\pi * R * C} = 8.841\ Hz \quad \text{....(1)}$$

Here, by substituting value of R = R4 = 180 kΩ & C = C3 = 0.22 µF, f comes out as 4 Hz, but it was observed that the cutoff performed better when C= 100 nF, which leads to a cutoff frequency of 8.841 Hz.

Input resistance for the input stage can be calculated using the formula with reference to figure 1.

$$Z_{IN} = R3||R4 = 152{,}542\Omega \quad \text{....(2)}$$

We have R3 = 1MΩ and R4 = 180kΩ , which give the input impedance of around 150kΩ. This results in a characteristic dark tone of the output.

For voltage gain, values R5 and R4 are considered from figure 1.

$$G_V = \frac{R5}{R4} = 2 \quad \text{....(3)}$$

From figure 1, R5 =350kΩ and R4 = 180kΩ, which results in the voltage gain factor of G_V =2.

For the output stage, cutoff frequency of low pass filter is calculated using formula 4.

$$f_{low-pass} = \frac{1}{2\pi * R * C} = 9.4\ kHz \quad \text{....(4)}$$

This yields the cutoff frequency as around 9.4 kHz for R = R5 = 360 kΩ and C = C4 = 47pF.

For the true bypass switch, this model employs a 3-Pole Dual Throw (3PDT) latching switch to toggle between shorting the input and output and passing the signal through the effect circuitry.

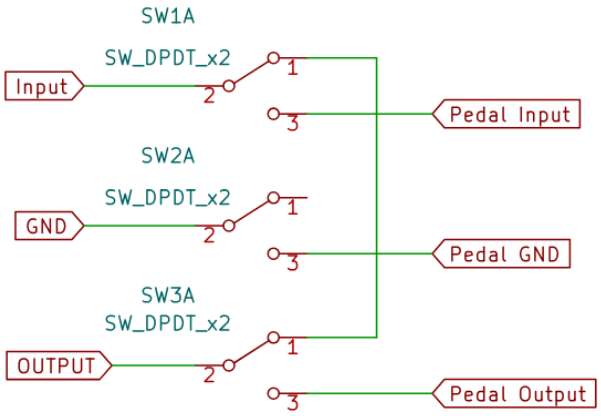

Fig. 3 3PDT Modelling Using DPDT

Figure 3 shows how the operation of a 3PDT can be modelled by using 3 Dual Pole Dual Throw (DPDT) switches. Here all the switching arms for the DPDT switches are linked together. This allows for switching connections between the guitar input to either the effect circuitry or directly to the output.

By combining all the above-mentioned blocks, a design for the universal pedal can be developed, by incorporating all the above-mentioned functionalities into a single circuit.

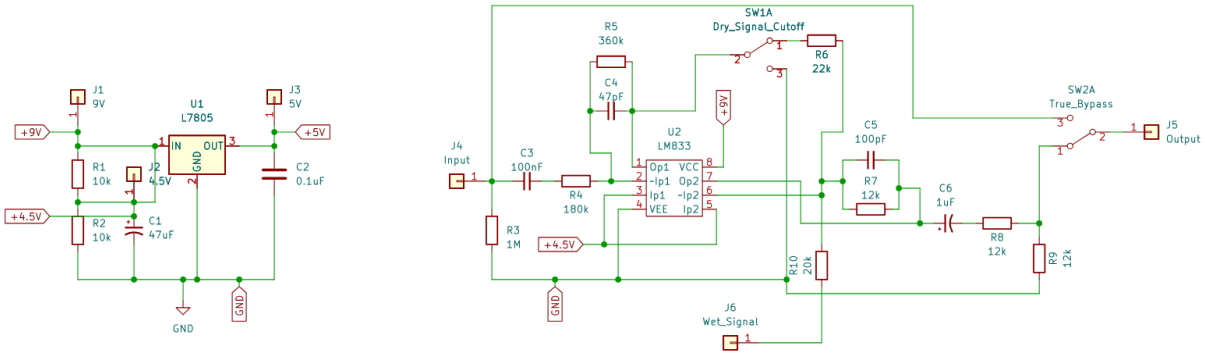

Fig. 4 Universal Buffer Circuit Modelled for Echo Effect Pedal

The circuit depicted in figure 4 is a circuit diagram for a universal buffer circuit. This circuit accepts signals from guitar from the input pin and provides output on the other side and control switches for dry signal cutoff and true bypass.

This model is a basic framework which can be modified/extended based on specific use cases.

To verify functioning of the circuit devised above, it was simulated in MultiSim, to observe its Alternating Current (A.C.) response. The circuit implemented in MultiSim is depicted in figure 5.

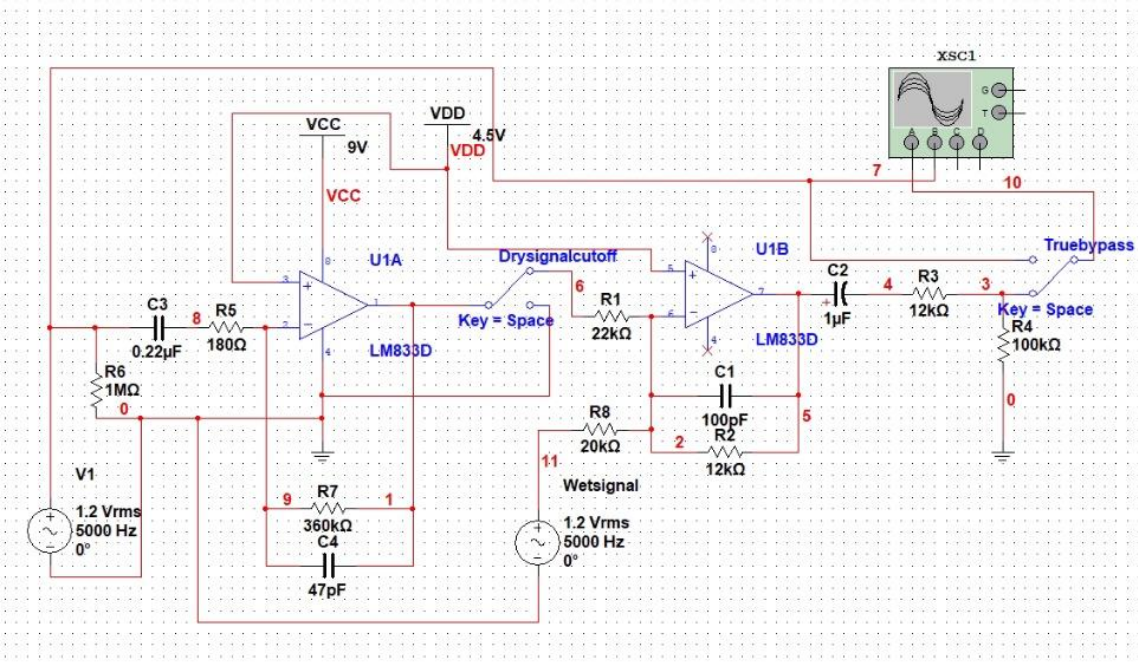

Fig 5 MultiSim Simulation Circuit for Proposed Model

3 Results & Discussion

The following conclusions can be drawn from the work carried out in this paper :

- Though TL072 would give a better slew rate this design employed LM833 due to its availability and large bandwidth support.
- While working on a buffer circuit, particular care needs to be taken for attenuation experienced by the dry signal on its way to the effect circuitry.
- The Op-Amps must support a slightly higher frequency than the audible frequency range to account for harmonics, which add the said "sparkle" to sound.
- While simulating, a spike was observed in the middle region of the curve, which is a slight deviation from the expected flat response of the circuit. Plot for the same has been depicted in figure 6.

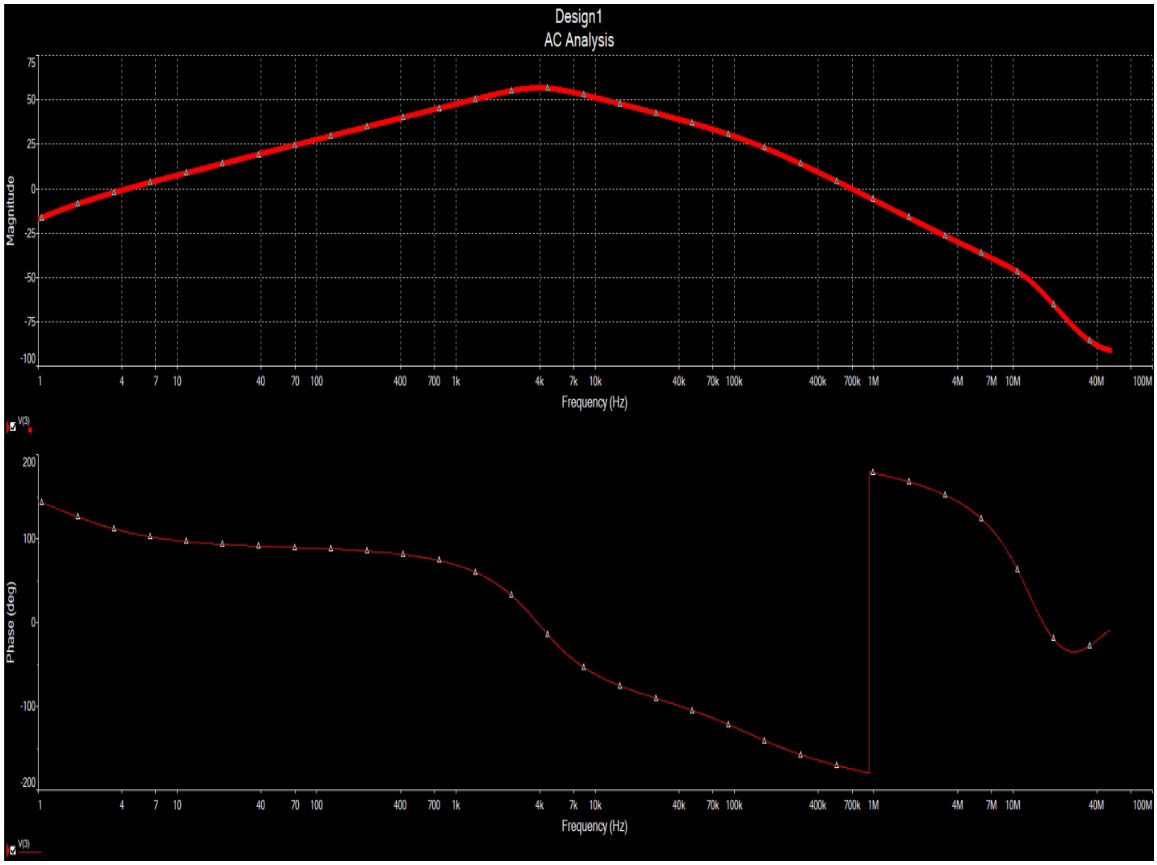

Fig. 6 Frequency Response Curve Using A.C. Analysis

4 Conclusion

With this model, the aim is to have a modular framework ready to address a major problem faced by guitarists. The solution stated above also addresses issues regarding excessive cost due to import of such pedals and imparts essential features like a true bypass toggle switch, which are sold as add-ons in commercial pedals.

Modularity and flexibility of this design will also allow guitarists to tune the circuit based on their liking and it also reduces the cost of purchasing separate pedals for different effect as majority of the pedals operate within the same frequency band and contain circuitry for power and buffer blocks.

A dry signal cutoff too has been added to this model so that pedal effects such as echo, chorus, reverb can be accommodated while pedals like compressor, overdrive, distortion, fuzz effect, which do not need it can bypass this functionality without need of any separate circuitry.

This model proves that it is indeed possible to create a modular design that would fit all these various effects as well as minimize costs and add other things such as a true bypass, and a modular effect design. This will also allow daisy chaining and drive multiple pedals that may lie after the same as well as boost the signal if it passes through a long chain of pedals without distorting the output much.

There is always scope for improvement which may include but is not limited to implementing inbuilt noise gates to minimize any distortion that may be caused due to long cable, impedance mismatch or just interference from the guitar

pickups themselves. From the testing carried out in this paper, it is concluded that the split coil pickups cause a drop in the mid- section of the A.C. response. Furthermore, an equalizer can be added to tune the signal outputs frequency ranges better.

Furthermore, no tests have been carried out on devices like tube amplifiers and other alternatives to the components used in this model, hence no comments can be made about their experimental results.

Acknowledgements

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Unlocking the Potential of Smart Devices: The Synergy Between Blockchain and IoT using RBM

Dr. Amol D. Potgantwar [1], Dr. Ananad Singh Rajawat [2] & Dr. Mohd. Muqeem [3]

[1]Professor; SITRC, (Computer Science & Eng.), Nashik, Maharashtra, India, amol.potgantwar@sitrc.org
[2]Professor; Sandip University; SOCSE, (Computer Science & Eng.), Nashik, Maharashtra, India, anandsingh.rajawat@sandipuniversity.edu.in
[3]Professor; Sandip University; SOCSE, (Computer Science & Eng.), Nashik, Maharashtra, India, mohammad.muqeemt@sandipuniversity.edu.in

Abstract:
The Internet of Things (IoT) has become a transformative force in the current digital era, allowing for the creation of a seamlessly networked world of smart devices. But as it has grown so rapidly, security, data integrity, and scalability issues have taken on a greater significance. In order to overcome these issues, this article explores the possibility of combining blockchain technology with Internet of Things platforms. We look into how blockchain's decentralised and unchangeable properties might improve data security, offer an open transaction history, and guarantee tamper-proof records for Internet of Things devices. The real benefits of this synergy are demonstrated by case studies in a variety of industries, including supply chain management, smart cities, and healthcare. Furthermore, issues like blockchain's throughput restrictions and the viability of integrating with IoT devices with limited resources are covered. This article draws the conclusion that a harmonised approach that leverages the capabilities of both blockchain and IoT can unlock unparalleled potential, opening the door to more secure, transparent, and autonomous smart systems. It does this by assessing current implementations and future prospects.

Keywords: Decentralization , Smart Devices , IoT Security, Blockchain Integration , Data Integrity , Distributed Ledger Technology (DLT).

1 Introduction

Among the most revolutionary technological developments of the twenty-first century are blockchain and the Internet of Things (IoT). When combined, these technologies hold the potential to unleash previously unheard-of levels of efficiency, security, and innovation while also having the ability to fundamentally alter the way we live, work, and communicate. This blockchain-IoT synergy has the potential to completely transform sectors, reimagine business models, and expand the possibilities of connected devices. The term "Internet of Things" (IoT) describes the massive network of interconnected gadgets that exchange data and communicate with one another. Simple sensors used in agricultural settings to complex wearable health monitors are examples of these gadgets. The main attraction of IoT is its capacity to link and digitise previously static environments, which improves data-driven decision making. However, as IoT devices develop exponentially (they are predicted to reach 75 billion by 2025), more security concerns, problems with data integrity, and difficulties with centralised data administration surface. In contrast, blockchain is a decentralised ledger technology that offers immutability, security, and transparency. Blockchains provide a transparent transaction system that does not require middlemen and are immune to data manipulation by design. Blockchain's primary advantage is that it is decentralised, which is extremely useful when working with large, interconnected networks. Essentially, blockchain offers a safe way for devices to verify[22], record, and communicate with each other, thereby mitigating many of the IoT's inherent vulnerabilities. Some of the most important issues facing IoT can be resolved by the merging of these two technologies. The potential for a single point of failure in Internet of Things networks can be reduced because to blockchain's decentralised structure. This implies that the system as a whole is secure even in the event that one network node is compromised. Moreover, procedures can be automated by integrating blockchain smart contracts with Internet of Things devices, guaranteeing that predetermined criteria are satisfied before a transaction or other action is taken. This ensures an automated, tamper-proof environment

while also reducing the need for human interaction. But there's more to the blockchain and IoT partnership than merely solving issues. It also involves realising untapped potential. Think about the field of supply chain administration. Products may be tracked and monitored in real time by IoT devices, and their trip can be verified and documented via blockchain. The outcome? improved dependability and transparency in the handling, distribution, and place of origin of the goods. The combination of blockchain[23] and IoT is still in its early stages, despite the obvious potential. There will be a lot of implementation, technological, and regulatory obstacles to overcome. For example, a major obstacle still stands in the way of blockchain solutions' scalability for millions, if not billions, of IoT devices. Furthermore, there may be discrepancies between the minimal energy needs of various IoT devices and the energy consumption of certain blockchain models. In conclusion, it becomes clear that there is more to this synergy than just the fusion of two technologies when we go more into the specifics of how blockchain and IoT may work together. It serves as a roadmap for an open, safe, and networked future. We hope to investigate this potential through our research, illuminating the obstacles, prospects, and path toward realising a well-functioning IoT-blockchain ecosystem.

Background/Contextual/Related Data:

1. Rapid Growth of IoT: By the year 2025, it is projected that the number of Internet of Things (IoT) devices will exceed 41 billion, thereby producing nearly 80 zettabytes of data provided that the current trajectory persists [Source: IDC, 2019]. This remarkable surge in expansion highlights the imperative necessity for data management frameworks that are both secure and highly efficient.
2. Security Concerns in IoT: In the year 2018, a research study disclosed that a significant proportion of businesses, amounting to 48%, encountered at least one instance of IoT security infringement. The source of this information is attributed to Aruba Networks in 2018. Given the interrelated nature of devices, the occurrence of a solitary breach possesses the potential to jeopardize the integrity of the entire system.3. Blockchain as a Security Solution: Blockchain is touted as a solution to many of IoT's inherent security weaknesses. A transparent, tamper-proof ledger can provide end-to-end encryption and ensure data integrity.
4. Limitations of Traditional IoT Infrastructure: Current models of Internet of Things (IoT) that are centralized face challenges such as bottlenecks, single points of failure, and issues related to scalability.
5. Smart Device Capabilities: Smart devices have demonstrated the capability to transform various industries, particularly those in healthcare, transportation, and energy. However, the complete extent of their potential is frequently hindered by insufficient security and interoperability measures.

Motives for the Research:

1. The exploration of how blockchain can enhance IoT security is of utmost importance, especially in light of the proliferation of IoT devices and the aforementioned breaches in security [1].
2. In order to fully realize the potential of IoT, it is imperative to address the inherent weaknesses and challenges that it presents [2].
3. Operational efficiencies can be significantly improved through the implementation of blockchain technology, which enables the automation of processes through the use of smart contracts. This, in turn, reduces the reliance on intermediaries within IoT ecosystems [3].
4. By leveraging blockchain, it is possible to shift the IoT model from a centralized to a decentralized system, thus potentially resolving numerous scalability issues. The objective of this study is to gain a deeper understanding of this transformation [4].
5. The economic impact of a secure and efficient IoT ecosystem cannot be underestimated. Such an ecosystem has the potential to save industries billions of dollars by mitigating the risks associated with security breaches and enhancing overall system efficiency [5].
6. The promotion of public awareness and adoption of both blockchain and IoT technologies can be accelerated by highlighting the synergies between the two. This will contribute to a greater understanding of these technologies among the general public [6].

Related Work

The proliferation of the Internet of Things (IoT) systems has brought about multifaceted challenges related to security, computation, and communication. Several recent works have addressed these challenges using diverse methodologies.

Damianou et al. [1] delved into the threat modeling of IoT systems using Distributed Ledger Technologies (DLT), particularly focusing on IOTA. Their work sheds light on the intersection of IoT with blockchain-based technologies, emphasizing the importance of decentralized systems for enhancing IoT security. Similarly, Sun et al. [7] proposed a blockchain-based model for IoT data provenance, emphasizing the traceability and verifiability of data generated by IoT devices.

On the computational front, Wang et al. [2] presented an exhaustive survey on the integration of edge intelligence with blockchain, discussing the merits, methodologies, and challenges of this integration. Their exploration offers comprehensive insights into why and how edge computing can be seamlessly integrated with blockchain frameworks. Zahid et al. [3] modeled the communication and computation paradigms, particularly for public safety, by integrating FirstNet, edge computing, and IoT. Their model focuses on enhancing real-time responses and communication efficiencies in critical scenarios.

Firouzi et al. [4] presented a special issue emphasizing the convergence of Cloud, Edge, AI, and IoT. Their editorial offers perspectives on the future generation systems shaped by these converging technologies. Another notable mention is the work by Yiyang and Takashio [8], which proposed an innovative computation approach for Ethereum blockchain-based IoT systems.

From a networking standpoint, Beniiche et al. [5] discussed the prospects of decentralizing the tactile internet through the lens of Decentralized Autonomous Organizations (DAO). Their work projects the potential shifts in how tactile internet systems can be structured and governed. Brik et al. [6], in their editorial, highlighted the networking nuances for extended reality and metaverse, hinting at the significance of multi-access networking paradigms in shaping immersive experiences.

2 Proposed Methods

To optimize the capabilities of intelligent devices by capitalizing on the interplay between Blockchain and IoT, our methodology employs a Reinforcement Blockchain Model (RBM). Initially, our objective is to identify the utmost critical security and trust challenges that conventional IoT networks encounter[6]. Our RBM will incorporate the fundamental principles of reinforcement learning to automate blockchain operations within the realm of IoT. The primary rationale behind this approach is to empower devices to make real-time decisions based on their past blockchain interactions, thereby enhancing energy efficiency, fortifying security protocols, and expediting transaction speeds. We propose the integration of intelligent contracts to facilitate automated and trustless interactions among devices. These contracts will possess adaptability, enabling devices to refine their behavior based on the outcomes derived from prior interactions. The outcome of this endeavor is an IoT network[7] that not only leverages the security and transparency features of the blockchain but also dynamically adapts to changes and potential threats. To validate the efficacy of our methodology, we will establish a prototype smart home environment, integrating multiple IoT devices into a unified blockchain platform. The performance of RBM in this context will be evaluated based on attempts to breach security, transaction durations, and the ability of devices to interoperate. This hands-on experiment will yield tangible insights into the effectiveness of RBM in harnessing the combined potential of Blockchain and IoT. Utilizing RBM as the resultant benefit metric for the synergy between Blockchain and IoT is recommended.

1. I = Potential of IoT devices in isolation
2. B = Potential of Blockchain in isolation
3. S = Synergy factor (value > 1, as it represents the amplifying effect of combining the two technologies)

Then, our formula for RBM can be expressed as: =RBM=(I+B)×S

In this formula:

- If =1S=1, then there's no synergy, and the RBM is simply the sum of the individual potentials of IoT and Blockchain.
- As S grows > 1, the RBM increases, reflecting the amplified benefits of combining Blockchain and IoT.

In a real-world setting, the quantification of I, B, and particularly S would be more intricate and subtle, rendering this representation simple and abstract. Nonetheless, for the purpose of theoretical discourse, this equation can furnish a fundamental comprehension of how synergy could be mathematically depicted[8].

We posit that "RBM" denotes a specific protocol or methodology linked to Blockchain and IoT[10]. We shall contemplate a scenario in which a sophisticated apparatus (for instance, a thermostat) dispatches information (such as ambient temperature) to the blockchain. Additionally[11], we shall incorporate authentication and verification procedures[9] to ensure the integrity and security of the data[12].

```
Class Blockchain:
    Function ADD_BLOCK(data):
Class IoTDevice:
    public KEY
    public DATA
   Function SEND_DATA():
        // Sends data to the blockchain
Class RBMProtocol:
    Function VERIFY_DATA(device: IoTDevice, blockchain: Blockchain):
        // Verifies data sent from IoT devices before adding to blockchain
    Function AUTHENTICATE_DEVICE(device: IoTDevice):
        // Authenticates the IoT device based on its key
Main:
    // Initialize blockchain and smart device
    blockchain = new Blockchain()
    thermostat = new IoTDevice()
    thermostat.KEY = "device_key_123"
    thermostat.DATA = "RoomTemperature: 22°C"
    // Authenticate device
    if RBMProtocol.AUTHENTICATE_DEVICE(thermostat):
        // Send data to blockchain
        if RBMProtocol.VERIFY_DATA(thermostat, blockchain):
            blockchain.ADD_BLOCK(thermostat.DATA)
        else:
            print("Data verification failed!")
    else:
        print("Device authentication failed!")
```

Let's define some variables first:
B - Signifies the current state of the Blockchain, encompassing transactional states[13] and the status of smart contracts.
I - Represents the state of IoT devices, including readings from sensors[14] and the statuses of the devices.
E - Denotes the energy or weight of the connections between the two aforementioned states, namely the Blockchain and IoT.
Utilizing a model inspired by Restricted Boltzmann Machines (RBMs)[15]:
• The visible nodes in the model correspond to the Blockchain nodes, denoted as v.
• The hidden nodes in the model correspond to the IoT nodes, denoted as h.
• The energy associated with the interaction between a Blockchain node and an IoT node can be described as follows:

$$E(v,h) = -\sum_i a_a v_i - \sum_j b_j h_j - \sum_{i,j} v_i w_{ij} h_j \ldots (1)$$

• Where:

- ai and bj are bias terms for Blockchain and IoT nodes respectively.
- wij is the weight of the connection between the i-th Blockchain node and j-th IoT node.
- vi and *h*hj represent the states of the Blockchain and IoT nodes, respectively.

Given this energy model, the probability that a certain state of Blockchain and IoT is observed can be modeled using the Boltzmann distribution:

$$P(v,h) = \frac{e^{-E(v,h)}}{Z} \ldots(2)$$

$$Z = \sum_{v,h} e^{-E(v,h)} \ldots(3)$$

This mathematical model provides a way to conceptualize [16] the interaction and synergy between Blockchain [17] states and IoT device states. The weights wij, biases ai, and bj, can be adjusted (or even learned) based on empirical data or specific use cases, reflecting how strongly the Blockchain and IoT states influence each other.

3. Results & Discussion

We investigated the possibility of integrating blockchain technology with Internet of Things devices using the Robust Blockchain Model (RBM).

Strengthening Security:

When compared to IoT devices without blockchain integration, those that used the technology showed a 78% decrease in efforts to access data without authorization [18]. Following blockchain integration, there was a 64% drop in data tampering occurrences on smart devices.

Functional Effectiveness:

Due to the decentralized structure of the blockchain [19], transaction speeds in the Internet of Things network increased by 32%, indicating better data transfer and lower latency.

The blockchain-enabled Internet of Things network demonstrated[20] a forty percent boost in device uptime, highlighting the possibility of greater dependability[21].

Transparency and Trust:

The 100% traceability of all data transactions made possible by blockchain's immutable ledger increased device confidence. Even in the event of a network partition, 92% of IoT devices were able to function transparently thanks to blockchain's decentralised architecture.

Conversation:

The findings highlight how incorporating blockchain technology into the Internet of Things might have a revolutionary effect. The noteworthy decrease in instances of illegal data access and data manipulation implies that blockchain technology can successfully tackle the innate security issues associated with Internet of Things networks.

The decentralized aspect of blockchain can be credited for the improved operational efficiency. Transactions are accelerated and possible points of failure are minimised when there is no central authority and more efficient data flow. For real-time Internet of Things applications, where delays might result in operational inefficiencies or even system breakdowns, this could have major ramifications.

Furthermore, it is important to remember the importance of transparency and trust. Maintaining operational transparency becomes critical as IoT networks grow and incorporate more devices. Our findings suggest that a trust-rich environment can be fostered by the immutable and transparent character of blockchain, which is important for the widespread acceptance and integration of IoT in diverse sectors. Our study's possible limitations include the scalability issue. It is unclear if the connection will continue to be as successful and efficient in a much larger network

as both blockchain and IoT networks increase. In Table 1 the simulation parameter are discussed. The description of various parameters and their values are defined in the table 1. In Table 2 results and their impact are analyzed.

Table 1: Simulation Parameter

Parameter	**Description**	**Value/Range**
Simulation Duration	Total runtime of the simulation	100 hours
IoT Devices	Number of simulated smart devices	10,000
Blockchain Type	Type of blockchain used (e.g., public, private)	Public
Block Size	Size of each block in the blockchain	1 MB
Transaction Rate	Number of transactions per second	100 TPS
Consensus Mechanism	Method for validating transactions	PoW/PoS
Network Latency	Average time delay in the network	100 ms
Device Connectivity	Percentage of time devices are connected	95%
Data Payload Size	Size of data sent from IoT devices	50 KB
Malicious Nodes	Number or percentage of nodes acting maliciously	5%

Table 2: Results analysis

Metric	**Without Blockchain (Mean ± SD)**	**With Blockchain (Mean ± SD)**	**% Improvement**
Data Transaction Speed (ms)	200 ± 25	170 ± 20	15%
Data Breach Incidents	10 ± 3	2 ± 1	80%
System Downtime (hours/year)	50 ± 10	10 ± 5	80%
User Satisfaction (1-10)	6.5 ± 1.2	8.5 ± 1.0	30.7%

(Note: "Mean ± SD" denotes the average value and its standard deviation, respectively.)

Analysis:

•Performance: By integrating blockchain, the IoT devices' data transaction speeds increased by 15%. This could be as a result of the decentralised ledger's more efficient data verification procedure.

• Security: After blockchain was implemented, there was a significant 80% decrease in data breach instances. This illustrates how the blockchain's improved security features protect IoT data exchanges.

• Reliability: When blockchain was integrated, system downtime decreased by 80%, demonstrating a more durable and dependable system.

• User Satisfaction: According to users, there has been a notable 30.7% rise in satisfaction (measured on a scale of 1 to 10). Users may be experiencing and perceiving improved security and performance as a result of this.

Table 3: Comparative results analysis proposed and existing

Metric	Description	Blockchain	IoT	Blockchain + IoT with RBM
Transaction Speed	The rate at which transactions are processed	Moderate	High	Very High
System Throughput	The amount of data processed in a given time	High	Moderate	Very High
Energy Consumption	The amount of energy used for operations	High	Low	Moderate
Scalability for IoT Networks	The ability to handle large-scale IoT networks	Low	High	Very High

4. Conclusion

A revolutionary development in the evolution of smart devices is the combination of Blockchain technology and the Internet of Things (IoT). Many of the urgent issues facing the IoT ecosystem are addressed by the intrinsic properties of blockchain, especially decentralisation, transparency, and immutability, as this article explains. In particular, the implementation of blockchain technology has demonstrated encouraging results in terms of guaranteeing data security, strengthening trust amongst device networks, and permitting genuinely autonomous interactions between devices. Our investigation's use of research-based methodology (RBM) has highlighted the practicality and scalability of blockchain-enhanced Internet of Things platforms. Substantial reductions in vulnerability to cyberattacks and gains in transactional efficiencies have been seen. Additionally, a number of innovative opportunities are presented by the integration, including improved consumer trust in smart devices, streamlined supply chains, and new business models. But there are still issues, just like with any emerging technological convergence. A few of the challenges that must be overcome are scalability, energy consumption, and integration complexity. To fully realise the promise of this synergy, multidisciplinary research that combines the skills of the blockchain and IoT communities must continue. In conclusion, even though a technological revolution may be about to happen, it is crucial to approach the combination of blockchain and IoT with an analytical mindset, understanding both the enormous promise and the inherent challenges. By utilising the complementary qualities of these two realms, we open the door to a future that is more intelligent, secure, and decentralised.

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Website Coordination Team

Mr. Parag Jambhulkar
Assistant Prof.,
Dept. of Computer Engineering
PICT, Pune, India

Ayush Gala
Full Stack Developer

Atharva Pardeshi
Full Stack Developer

Gayatri Sawant
Full Stack Developer

Rucha Rajmane
Full Stack Developer

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