Secure AI-Driven Currency Recognition System for Visually Impaired Users: Integrating Network Security Measures for Data Protection

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***Abstract*— In recent days, the number of visually impaired people has been growing all over the world, and visually impaired people may suffer from money transactions (knowing each currency paper apart). So, there is some interest among many researchers in coming up with ways of providing assistive tools or technologies to help these people with monetary transactions. In this paper, we will provide a system for solving the problem of non-recognized Iraqi banknote currencies using AI recognition techniques and obtaining high-accuracy results. This model's result is very high, equaling approximately 100% testing and validation accuracy using mobile Architecture in less than 1 second.**

Keywords—Currency, Recognition, AI-Driven Security, Visually Impaired Users and Data Protection.

I. Introduction

It is possible that some people unknowingly utilize the phone. Those who are visually impaired (VI), however, could not fully enjoy this pastime. The majority of people nowadays take reading and writing for granted. The biggest worry may be that the user cannot read if they lose eyesight [1]. Numerous tools and resources enable users to read anything. From perusing medication labels to examining upcoming bestsellers. Visually challenged people may read newspapers and other articles using braille books, audiobooks, magnification devices, and smartphone applications. Visually impaired people have access to a wide range of reading aids. Remember that with any solution, the VI must acquire new ways to read and learn [2].

World Health Organization (WHO) estimated the numbers of VI and blind people. In 2018, there were over 1.3 billion people worldwide [3]. According to Community Eye Health Journal research, the number is increasing. The left axis illustrates the population of people that have moderate to severe visual impairment according to their ages in the bottom axis [4]. As an example, people that have ages 50 to 54, approximately 1 % of them all over the world, are blind, and the rest 5 % have moderate to severe visual impairment.

II. Literature Review

The recent developments in artificial intelligence technology have significantly improved vision-impaired assistive tools, especially for currency identification functions. Deep learning allows Ashraf Khalil et al. (2022) to create a mobile application for the United Arab Emirates (UAE) [5] banknote classification. The application uses a Convolutional Neural Network (CNN) trained on different denomination images to deliver real-time recognition feedback through sound to users [6]. The implemented system provides precision in identification and user convenience, becoming an essential device for visually impaired users in the UAE [7].

Dutta (2022) [8] developed the currency recognition system for VI people. Indian banknotes are recognized through an accurate detection method using the YOLO-v3 object detection algorithm [9]. Smartphone-camera-processed images allow the framework to provide audio reports about currency value automatically. The model demonstrates stable performance under different lighting situations, making it suitable for everyday applications [10].

The application of convolutional neural networks to detect and mitigate side-channel attacks highlights AI's potential to enhance security in sensitive data processing [11] allows visually impaired users to experience real-time surrounding detection and object perception. Through audio feedback, users obtain alerts for obstacles from the system because it utilizes deep-learning object detection with distance sensors [12]. The application of this technology demonstrates how AI can boost the mobility capabilities and independence of individuals whose vision is limited.

Integrating AI in assistive technologies necessitates a focus on data protection and cybersecurity. According to K. Renaud Lizzie Coles (2022) [13], designers must create cybersecurity measures that are accessible to users in their modern technology development [14]. Security features according to users' needs should be the focus because accessibility must remain available, and personal data protection should not be sacrificed when visually impaired people utilize assistive applications [15].

The discussion by Wiktoria Wilkowska *et al*. (2022)[16] focused on privacy awareness in lifelogging technologies that demonstrate similarities with assistive frameworks that handle continuous personal data processing. The authors explain that users should use robust passwords and encryption tools to protect their home networks and shield their data from hackers [17]. These security precautions prove essential in protecting the user data stored by AI-driven currency recognition systems.

Explored optimization techniques for deep learning models to enhance the detection of side-channel attacks, which supports the development of secure AI-driven systems [18][19].

Shojaei et al. (2020) [20] discuss health data protection through test-driven anonymization that safeguards personal information and preserves data utility. This methodology offers assistive technologies to make user data anonymous and reduce privacy risks during data collection and processing steps[21].

According to research by Eleni Gkiolnta et al. (2025) [22], developing digital assistive technologies requires ethical frameworks. The study examines the necessary protocols to guide technological implementations. It shows that users must consent while maintaining privacy during assisted solution development, and AI applications should be utilized responsibly to create effective systems that protect user rights [23].

III. METHODOLOGY

In [20][24], [25] a CRS for Jordanian papers was developed. For this purpose, they used the SIFT [26] algorithm called Scale Invariant-Feature Transform. They applied this feature extraction algorithm to a large dataset.

The steps for implementing this method are as follows:

- The currency paper is captured using a mobile camera.
- Some image processing functions are applied to remove noise and cut currency from the background.
- Apply the SIFT Algorithm to find (key points) high and low values pixels from neighbors.
- Find a descriptor around every key point to be matched later with tested descriptors—the flow diagram of this method is shown in Figure 1.

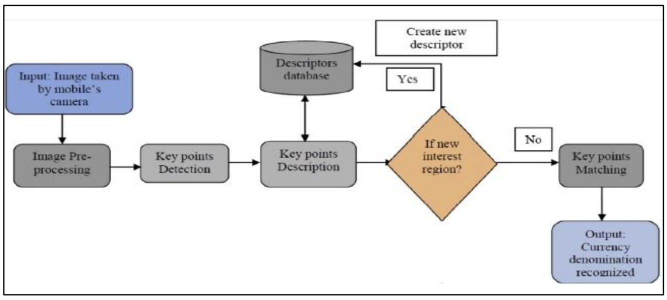


Figure 1. Flow diagram of CRS_SIFT approach

This approach is applied to paper currencies and coins. Figure 2 shows the accuracy and comparisons between the color and grey modes tested. The result of implementing the SIFT in the color mode is shown on the left, and the grey modes on the right.

Banknote type	Average correct recognition	Average processing time (s)
Paper Currency	0.71	72.9
Coin Currency	0.25	78.2

Banknote type	Average correct recognition	Average processing time (s)
Paper Currency	0.53	72.4
Coin Currency	0.20	80

Figure 2. Accuracy of CRS_SIFT methods in color and grey modes

In [27], they proposed for recognizing Saudi paper currencies. It uses a Radial Basis-Function network to classify currencies and uses a correlation function for the matching process. The accuracy of this method is different for every condition of images, as shown in Table 1.

TABLE 1. Accuracy of Saudi PCR

Tilted Image set	Noisy untilted Image set	Normal untilted-Image set	Average Recognition rate
87.5%	91.65%	95.37%	91.51%

This proposed method is shown in Figure 3, starting with banknote collecting and ending with the classification process.

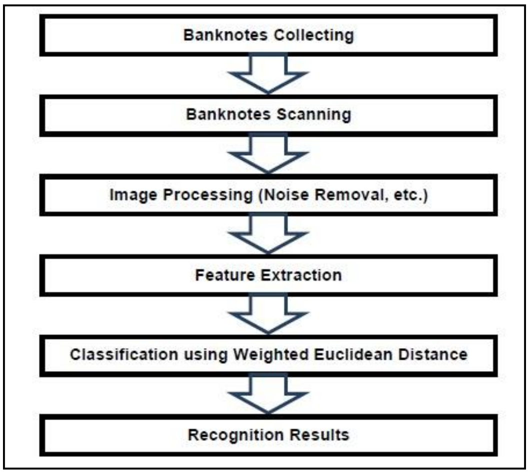


Figure 3. Saudi Currency Recognition Block Diagram

In [28], they proposed an Egyptian CRS for people with low vision. Firstly, after capturing the Image on an Android smartphone, they implemented some preprocessing functions to clean the Image from noise and to facilitate the segmentation process into black for the foreground and white for the background [29]. Then, they removed the background from the Image to get only the currency.

Then, they extracted the region of interest (ROI) [30]. ROI is the right corner of the currency with a specified number of pixels: 50* 50 pixels. They used a correlation function to match two objects [31]. This method's accuracy is 89 %, and it takes a long time to get a result: 12 seconds per test.

CRS has become one of the most interesting research areas in recent years. As mentioned in the previous chapters, the researchers have developed a wide range of CRS. Most research focused on currency recognition using MATLAB and scanners [32][33]. These methods are not convenient for VI persons. The other approaches have some limitations that influence the accuracy of the recognition.

IV. RESULTS

We implemented a system for recognizing Iraqi currencies using deep learning techniques. This system relies on using the MobileNet model. The currency will be tested with the trained model to classify it into the correct class of currencies [34]. The result will be shown on the screen and in the voice using text-to-speech (TTS) technology to enable visually impaired people or blind people to hear the result. This method has a test accuracy of 100 % and a validation accuracy of 100% for all kinds of currencies [35][36].

This system provides an easy way to recognize currencies without the intervention of the visually impaired. After opening the application using the Google Voice service by saying “ICR App,” the camera will open automatically, and the VI should put his currency in front of the camera [37]. The phone speaker will inform the currency's value after matching the currency features with the TensorFlow lite model[33]. Figure 4 shows the Android application user interface for ICR.

Figure 4 Android application (ICR)

A. Steps of training the model

1) Gathering the training data

The proposed system requires a large dataset of many images, so we used a simple data collection method. We took video recordings for every currency [38]. This video contains the front and back of each currency with different scaling, rotation, and illumination. The result for every banknote is an MP4 video [39]. Figure 5 shows the videos of the Iraqi currencies.

Figure 5. Videos of the Iraq Currencies.

2) FFMPEG (Fast Forward Motion Picture Experts Group)

Using the following command, we used this FFMPEG to split every video into useful images during training.

- ***ffmpeg -i dataset/fivehundred.mp4 -r 10***
- ***dataset/fivehundred/fivehundred_%04.jpg.***

Using FFMPEG, we created a big dataset of 3700 images per class from Iraq currencies. Figure 6 shows the process of splitting five hundred videos into images.

```
!ffmpeg -r 16 -i videos/10000_4.mp4  training_data/ten_thousands/d_%04d.jpg

ffmpeg version 3.4.8-0ubuntu0.2 Copyright (c) 2000-2020 the FFmpeg developers
  built with gcc 7 (Ubuntu 7.5.0-3ubuntu1~18.04)
  configuration: --prefix=/usr --extra-version=0ubuntu0.2 --toolchain=hardened
  libavutil      55. 78.100 / 55. 78.100
  libavcodec     57.107.100 / 57.107.100
  libavformat    57. 83.100 / 57. 83.100
  libavdevice    57. 10.100 / 57. 10.100
  libavfilter     6.107.100 /  6.107.100
  libavresample   3.  7.  0 /  3.  7.  0
  libswscale      4.  8.100 /  4.  8.100
  libswresample   2.  9.100 /  2.  9.100
  libpostproc    54.  7.100 / 54.  7.100
Input #0, mov,mp4,m4a,3gp,3g2,mj2, from 'videos/10000_4.mp4':
  Metadata:
    major_brand     : mp42
    minor_version   : 0
    compatible_brands: mp42isom
  Duration: 00:00:21.90, start: 0.000000, bitrate: 1588 kb/s
```

Figure 6. Process of splitting five hundred videos into images

3) Create a folder of images for every class of currencies.

In this step, we provide a folder for every currency with the resulting images from the previous step. Figure 7 shows the pictures folder for each currency.

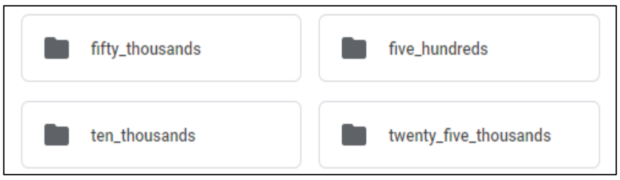


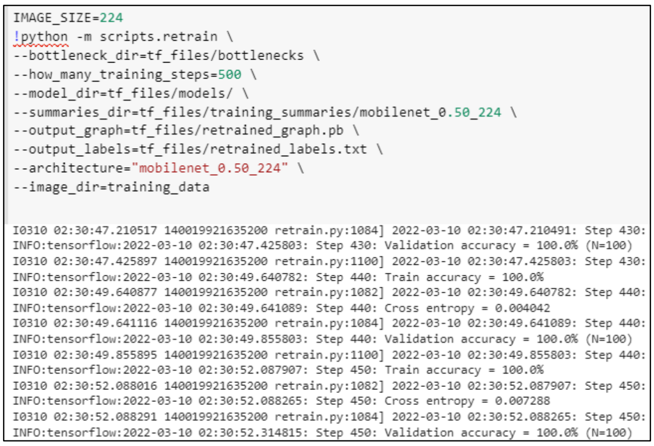
Figure 7. Folder of images for each currency.

4) Retraining the new images.

We used the Mobile Net V1 model. For on-device or embedded applications, this set of TensorFlow computer vision models gives mobile devices priority, improves accuracy, and saves resources [40] [41]. Demonstrated the effectiveness of hybrid AI models for classification tasks, which applies to improving the accuracy and efficiency of currency recognition frameworks [42]. MobileNets are compact, low-latency, and low-power models that address the resource constraints of various use cases. They may be utilized for segmentation, detection, embeddings, and classification in the same way as Inception and other famous large-scale models are made [43][44]. MobileNets are based on a streamlined architecture that uses depth-wise separable convolutions, which were explained in the background chapter [45]. They are used to build lightweight deep neural networks. Figure 8 shows the demo of training the model using the above commands [46].

The following code is the Python script implemented to retrain the new data with the model.

```
python -m scripts_retrain\
    --bottleneckDir=TFfiles/currencies\
    --trainingSteps=1000\
    --modelDir=TFfiles/models\
    --summariesDir=TFfiles/trainingSummaries/"
       mobile_net0.50_224" \
    --outputGraph=TFfiles/retrainedGraph.pb\
    --outputLabels=TFfiles/retrainedLabels.txt\
    --architecture=" mobile_net0.50_224"\
    --imageDir=trainingData/currencies
```



```
IMAGE_SIZE=224
!python -m scripts.retrain \
--bottleneck_dir=tf_files/bottlenecks \
--how_many_training_steps=500 \
--model_dir=tf_files/models/ \
--summaries_dir=tf_files/training_summaries/mobilenet_0.50_224 \
--output_graph=tf_files/retrained_graph.pb \
--output_labels=tf_files/retrained_labels.txt \
--architecture="mobilenet_0.50_224" \
--image_dir=training_data

I0310 02:30:47.210517 140019921635200 retrain.py:1084] 2022-03-10 02:30:47.210491: Step 430:
INFO:tensorflow:2022-03-10 02:30:47.425803: Step 430: Validation accuracy = 100.0% (N=100)
I0310 02:30:47.425897 140019921635200 retrain.py:1100] 2022-03-10 02:30:47.425803: Step 430:
INFO:tensorflow:2022-03-10 02:30:49.640782: Step 440: Train accuracy = 100.0%
I0310 02:30:49.640877 140019921635200 retrain.py:1082] 2022-03-10 02:30:49.640782: Step 440:
INFO:tensorflow:2022-03-10 02:30:49.641089: Step 440: Cross entropy = 0.004042
I0310 02:30:49.641116 140019921635200 retrain.py:1084] 2022-03-10 02:30:49.641089: Step 440:
INFO:tensorflow:2022-03-10 02:30:49.855803: Step 440: Validation accuracy = 100.0% (N=100)
I0310 02:30:49.855895 140019921635200 retrain.py:1100] 2022-03-10 02:30:49.855803: Step 440:
INFO:tensorflow:2022-03-10 02:30:52.087907: Step 450: Train accuracy = 100.0%
I0310 02:30:52.088016 140019921635200 retrain.py:1082] 2022-03-10 02:30:52.087907: Step 450:
INFO:tensorflow:2022-03-10 02:30:52.088265: Step 450: Cross entropy = 0.007288
I0310 02:30:52.088291 140019921635200 retrain.py:1084] 2022-03-10 02:30:52.088265: Step 450:
INFO:tensorflow:2022-03-10 02:30:52.314815: Step 450: Validation accuracy = 100.0% (N=100)
```

Figure 8. Demo of Training the model using the above commands.

This script will result in a retrained graph—pb file.

5) Optimizing for mobile (lite model)

After retraining our new dataset, we needed to convert the resulting file to be used in mobile development, so we used a TensorFlow lite converter, a technique provided by the TensorFlow library for this purpose [47]. We aim to convert the "**retrained_graph.pb**" to "**retrained_graph.tflite**" to be used in Android development for the classification process [48].

```
!toco\
--graphDef_files=TFfiles/retrainedGraph.pb\
--outputFile=TFfiles/model.tflite\
--inputFormat=TENSORFLOWgraphdef\
--outputFormat=TFLITE\
--inputShape=1,224,224,3\
--inputArray=input\
--outputArray=finalResult\
--inferenceType=FLOAT\
--inputDataType=FLOAT
```

B. *Steps of Adding TensorFlow model into an android project*

1) Locate the generated tensor-flow Model file and label the file on the local computer. Fig. 9 shows the model file and labels file on the local computer.

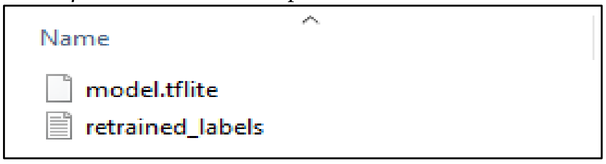


Figure 9. Model file and labels file on local computer

2) Copy two files into the assets folder in Android Studio. Figure 10 shows the model and label file after copying them into the assets folder.

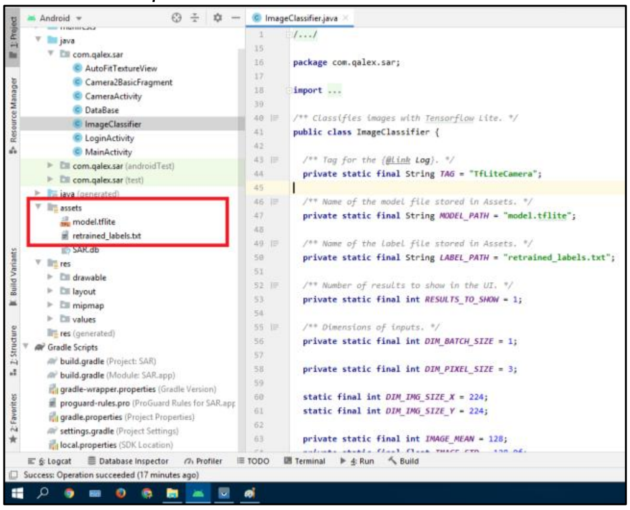


Figure 10. Model and Label files after copying them into the assets folder

3) In-camera activity: periodically take frames, convert them to bitmaps, and send them to the Image Classifier class for classification. Figure 11 shows the screen after converting frames to bitmaps and sending them to the model.

```
/*Takes frames and classify them*/
 PrivateRunnablePeriodic_Classify =
     newRunnable(){
       @ Override
       public void run(){
         synchronized(lock){
           if (run_Classifier){
             classify_Frame();
           } }
         background_Handler.post(periodic_Classify);
       } };
```

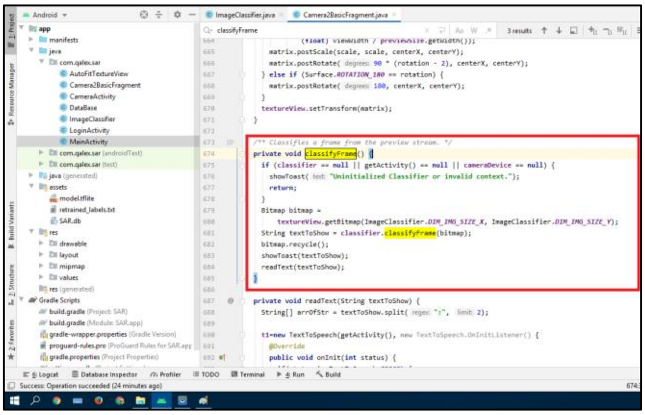


Figure 11. Screen from Converting frames to bitmaps and sending them to the model

4) In the Image Classifier, the bitmap is converted to a byte Buffer and sent to the tensor-flow model to perform classification and return the currency result.

```
/*Classifies a frame from a stream*/
String classify Frame(Bitmapbitmap) {
  if (t_flite == null){
    Log.e(TAG, "Image classifier has not been initialized; Skipped.");
    return “Uninitialised Classifier.”;
  }
  convertBitmap_ToByteBuffer(bitmap);
  long start_Time = System_Clock.uptime_Millis();
  t_flite.run(img_Data, labelProb_Array);// tflite is object that can deal with the model
  long end_Time = System_Clock.uptime_Millis();
  Log.d(TAG, "Timecost to run model inference: " + Long.toString(end_Time – start_Time));
  apply_Filter();
  String text_ToShow = print_TopKLabels();
  //text_ToShow = Long.to_String(end_Time – start_Time) + "ms" + text_ToShow;
  return text_ToShow;
}
```

5) The result returns for Camera activity with the currency value.

```
String textToShow = classifier.classifyFrame(bitmap);
```

6) The currency value is sent to the Text-To-Speech built-in class to be pronounced.

```
private void read text(String textToShow) {
   String[] arrOfStr = textToShow.split(":", 2);
   t1=newTextToSpeech(get_Activity(),
newText_ToSpeech.OnInit_Listener() {
     @Override
     public void on_Init(int status){
       if(status!= Text_ToSpeech.ERROR) {
         t1.setLanguage(Locale.US);
         t1.speak(arrOfStr[0], Text_ToSpeech.QUEUE_FLUSH, null);
       } }   }); }
```

Finally, we executed the Build Project and run on an Android smartphone for testing.

V. CONCLUSION

In this article, we have introduced a mobile-based currency recognition framework for blind and VI people using image processing and AI techniques. It depends on collecting datasets from Iraq currency papers and applying some image processing and AI algorithms to extract features of currency paper and then save it to a model. This model is used in recognition when blind people place the currency behind the camera. The matching process begins with recognizing the currency’s value and returning the voice with the result. It depends on collecting datasets from Iraq currency papers and applying training on this dataset using transfer learning based on the Mobile Net model. The application is tested on Android smartphones. This model's result is very high, equal to approximately 100% of testing and validation accuracy with a short time of less than 1 second.

CONFLICT OF INTEREST

The authors declare that this research is free of conflicts of interest. We have no financial or personal relationships that could bias or influence our research.

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REFERENCES

[1] S. E. A. Alnawayseh, W. T. Al-Sit, and T. M. Ghazal, “Smart Congestion Control in 5G/6G Networks Using Hybrid Deep Learning Techniques,” *Complexity*, vol. 2022, 2022, doi: 10.1155/2022/1781952.

[2] M. Hanif *et al.*, “A Novel Grayscale Image Encryption Scheme Based on the Block-Level Swapping of Pixels and the Chaotic System,” *Sensors*, vol. 22, no. 16, 2022, doi: 10.3390/s22166243.

[3] K. He, X. Zhang, S. Ren, and J. Sun, “Global estimates of visual impairment: 2010,” *bjo.bmj.com*, Accessed: Feb. 21, 2025. [Online]. Available: https://bjo.bmj.com/content/96/5/614.short

[4] M. M. Abualhaj, Q. Y. Shambour, A. A. Abu-Shareha, S. N. Al-Khatib, and A. Amer, “Enhancing malware detection through self-union feature selection using gray wolf optimizer,” *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 37, no. 1, pp. 197–205, 2025, doi: 10.11591/ijeecs.v37.i1.pp197-205.

[5] A. Khalil, M. Yaghi, T. Basmaji, … M. F.-… on F. I. of, and undefined 2022, “Mobile Deep Classification of UAE Banknotes for the Visually Challenged,” *ieeexplore.ieee.org*, Accessed: Feb. 21, 2025. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9910510/

[6] M. T. Alshurideh *et al.*, “An Experimental Evaluation on Resource Attribute, Internal Risks and Regime Structure of R&D Association-Including Exploration of Moderating Effect of Association Management Capability, Psychological,” *Journal for ReAttach Therapy and Developmental Diversities*, vol. 5, no. 2, pp. 201–215, 2022.

[7] M. U. Nasir *et al.*, “Kidney Cancer Prediction Empowered with Blockchain Security Using Transfer Learning,” *Sensors*, vol. 22, no. 19, 2022, doi: 10.3390/s22197483.

[8] R. Joshi, S. Yadav, M. D.-2020 I. Conference, and undefined 2020, “YOLO-v3 based currency detection and recognition system for visually impaired persons,” *ieeexplore.ieee.org*, Accessed: Feb. 21, 2025. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9077137/

[9] J. I. Janjua, S. Kousar, A. Khan, A. Ihsan, T. Abbas, and A. Q. Saeed, “Enhancing Scalability in Reinforcement Learning for Open Spaces,” *2024 International Conference on Decision Aid Sciences and Applications (DASA)*, pp. 1–8, Dec. 2024, doi: 10.1109/DASA63652.2024.10836237.

[10] L. Abualigah *et al.*, “Salp swarm algorithm: survey, analysis, and new applications,” in *Metaheuristic Optimization Algorithms:*

Optimizers, Analysis, and Applications, 2024, pp. 241–258. doi: 10.1016/B978-0-443-13925-3.00009-1.

[11] A. Ahmed, M. Hasan, … A. A.-2023 I. 21st, and undefined 2023, “Efficient convolutional neural network based side channel attacks based on AES cryptography,” *ieeexplore.ieee.org*, Accessed: Feb. 21, 2025. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/10563332/

[12] A. Al Saaidah *et al.*, “Enhancing malware detection performance: leveraging K-Nearest Neighbors with Firefly Optimization Algorithm,” *Multimed Tools Appl*, 2024, doi: 10.1007/s11042-024-18914-5.

[13] K. Renaud and L. Coles-Kemp, “Accessible and Inclusive Cyber Security: A Nuanced and Complex Challenge,” *SN Comput Sci*, vol. 3, no. 5, Sep. 2022, doi: 10.1007/S42979-022-01239-1.

[14] C. Sharma, G. Singh, P. S. Muttum, and S. Mahajan, “CNN-FastText Multi-Input (CFMI) Neural Networks for Social Media Clickbait Classification,” *Recent Advances in Computer Science and Communications*, vol. 17, no. 6, 2024, doi: 10.2174/0126662558283914231221065437.

[15] A. Alsaaidah, O. Almomani, A. A. Abu-Shareha, M. M. Abualhaj, and A. Achuthan, “ARP Spoofing Attack Detection Model in IoT Networks Using Machine Learning: Complexity vs. Accuracy,” *Journal of Applied Data Sciences*, vol. 5, no. 4, pp. 1850–1860, 2024, doi: 10.47738/jads.v5i4.374.

[16] W. Wilkowska *et al.*, “Interdisciplinary perspectives on privacy awareness in lifelogging technology development,” *SpringerW Wilkowska, J Offermann, L Colonna, F Florez-Revuelta, P Climent-Pérez, A MihailidisJournal of Ambient Intelligence and Humanized Computing, 2023•Springer*, vol. 14, no. 3, pp. 2291–2312, Mar. 2023, doi: 10.1007/s12652-022-04486-5.

[17] A. Al sarayreh *et al.*, “Examining the Effects of Gamified Human Resource Management on Job Performance of IT Startups,” in *Studies in Systems, Decision and Control*, vol. 226, Jadara University, Irbid, Jordan: Springer Science and Business Media Deutschland GmbH, 2024, pp. 203–216. doi: 10.1007/978-3-031-73545-5_18.

[18] A. Ahmed, M. Hasan, … N. N.-2023 33rd, and undefined 2023, “Optimization Technique for Deep Learning Methodology on Power Side Channel Attacks Reading list,” *ieeexplore.ieee.org*, Accessed: Feb. 21, 2025. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/10368481/

[19] A. Sharma, A. Nayyar, K. J. Singh, D. S. Kapoor, K. Thakur, and S. Mahajan, “An IoT-based forest fire detection system: design and testing,” *Multimed Tools Appl*, vol. 83, no. 13, pp. 38685–38710, 2024, doi: 10.1007/s11042-023-17027-9.

[20] P. Shojaei, E. Vlahu-Gjorgievska, Y. C.- Computers, and undefined 2024, “Security and privacy of technologies in health information systems: A systematic literature review,” *mdpi.comP Shojaei, E Vlahu-Gjorgievska, YW ChowComputers, 2024•mdpi.com*, 2024, doi: 10.3390/computers13020041.

[21] M. S. Aslam *et al.*, “Energy-efficiency model for residential buildings using supervised machine learning algorithm,” *Intelligent Automation and Soft Computing*, vol. 30, no. 3, pp. 881–888, 2021, doi: 10.32604/iasc.2021.017920.

[22] E. Gkiolnta, D. Roy, G. F.- Technologies, and undefined 2025, “Challenges and Ethical Considerations in Implementing Assistive Technologies in Healthcare Reading list,” *mdpi.com*, Accessed: Feb. 21, 2025. [Online]. Available: https://www.mdpi.com/2227-7080/13/2/48

[23] A. Al Sharah, Y. A. Alrub, H. A. Owida, E. A. Elsoud, N. Alshdaifat, and H. Khtatnaha, “An Adaptive Framework for Classification and Detection of Android Malware,” *International Journal of Interactive Mobile Technologies* , vol. 18, no. 21, pp. 59–73, 2024, doi: 10.3991/ijim.v18i21.49669.

[24] J. Zurada, “Introduction to artificial neural systems Reading list,” 1992, Accessed: Feb. 21, 2025. [Online]. Available: https://dl.acm.org/doi/abs/10.5555/131393

[25] B. abdulkareem Farhan, … A. N.-2023 S., and undefined 2023, “Design and Implementation of a Training Educational Board for Electromagnetic Control Experiments Reading list,” *ieeexplore.ieee.org*, Accessed: Feb. 21, 2025. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/10346862/

[26] “SIFT feature matching algorithm with global information - Google Scholar.” Accessed: Feb. 21, 2025. [Online]. Available: https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=SIFT+feature+matching+algorithm+with+global+information+&btnG=

[27] I. Doush, A. S.-J. of K. S. U.-C. and, and undefined 2017, “Currency recognition using a smartphone: Comparison between color SIFT and gray scale SIFT algorithms Reading list,” *Elsevier*, Accessed: Feb. 21, 2025. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1319157816300416

[28] N. Semary, S. Fadl, … M. E.-2015 5th I., and undefined 2015, “Currency recognition system for visually impaired: Egyptian banknote as a study case Reading list,” *ieeexplore.ieee.org*, Accessed: Feb. 21, 2025. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/7426896/

[29] S. A. K. Basha *et al.*, “Exploring Deep Learning Methods for Audio Speech Emotion Detection: An Ensemble MFCCs, CNNs and LSTM,” *Applied Mathematics and Information Sciences*, vol. 19, no. 1, pp. 75–85, 2025, doi: 10.18576/amis/190107.

[30] E. Suharto, A. Widodo, E. S.-J. of Physics, and undefined 2020, “The use of mobilenet v1 for identifying various types of freshwater fish Reading list,” *iopscience.iop.org*, Accessed: Feb. 21, 2025. [Online]. Available: https://iopscience.iop.org/article/10.1088/1742-6596/1524/1/012105/meta

[31] M. L. Shuwandy *et al.*, “Sensor-based authentication in smartphone: A systematic review,” *Journal of Engineering Research (Kuwait)*, 2024, doi: 10.1016/j.jer.2024.02.003.

[32] N. Nasser, A. Ali, L. Karim, A. A.-H.-S. preprints, and undefined 2024, “Enhancing mobility for the visually impaired with ai and iot-enabled mobile applications,” *scienceopen.comN Nasser, AY Ali, L Karim, AA Al-HelaliScienceOpen preprints, 2024•scienceopen.com*, Apr. 2024, doi: 10.14293/PR2199.000775.v2.

[33] A. A. Ahmed, M. K. Hasan, S. A. M. Noah, and A. H. Aman, “Design of Time-Delay Convolutional Neural Networks (TDCNN) Model for Feature Extraction for Side-Channel Attacks,” *International Journal of Computing and Digital Systems*, vol. 16, no. 1, pp. 341–351, Jul. 2024, doi: 10.12785/IJCDS/160127.

[34] F. Elghaish, S. Matarneh, E. Abdellatef, F. Rahimian, M. R. Hosseini, and A. Farouk Kineber, “Multi-layers deep learning model with feature selection for automated detection and classification of highway pavement cracks,” *Smart and Sustainable Built Environment*, 2024, doi: 10.1108/SASBE-09-2023-0251.

[35] H. N. Fakhouri, M. A. Alsharaiah, A. K. Al Hwaitat, M. Alkalaileh, and F. F. Dweikat, “Overview of Challenges Faced by Digital Forensic,” in *2nd International Conference on Cyber Resilience, ICCR 2024*, 2024. doi: 10.1109/ICCR61006.2024.10532850.

[36] M. U. Nasir, M. A. Khan, M. Zubair, T. M. Ghazal, R. A. Said, and H. Al Hamadi, “Single and Mitochondrial Gene Inheritance Disorder Prediction Using Machine Learning,” *Computers, Materials and Continua*, vol. 73, no. 1, pp. 953–963, 2022, doi: 10.32604/cmc.2022.028958.

[37] N. Turab, H. A. Owida, and J. I. Al-Nabulsi, “Harnessing the power of blockchain to strengthen cybersecurity measures: a review,” *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 35, no. 1, pp. 593–600, 2024, doi: 10.11591/ijeecs.v35.i1.pp593-600.

[38] A. Khalifeh *et al.*, “the Influence of Students’ Self-Control and Smartphone E-Learning Readiness on Smartphone-Cyberloafing,” *Journal of Information Technology Education: Research*, vol. 23, 2024, doi: 10.28945/5307.

[39] A. A. A. Sharabati, A. A. A. Ali, M. I. Allahham, A. A. Hussein, A. F. Alheet, and A. S. Mohammad, “The Impact of Digital Marketing on the Performance of SMEs: An Analytical Study in Light of Modern Digital Transformations,” *Sustainability (Switzerland)*, vol. 16, no. 19, 2024, doi: 10.3390/su16198667.

[40] H. J. Mutasharand, A. A. Muhammed, and A. A. Ahmed, “Design of Deep Learning Methodology for Side-Channel Attack Detection Based on Power Leakages,” *Lecture Notes in Networks and Systems*, vol. 977 LNNS, pp. 207–219, 2025, doi: 10.1007/978-981-97-2671-4_16.

[41] R. Thakur, A. Thakur, R. K. Viral, and D. Asija, “AI Based Visual Impairment System for Blind and People with Least Reading Capabilities,” *2024 IEEE Students Conference on Engineering and Systems: Interdisciplinary Technologies for*

Sustainable Future, SCES 2024, 2024, doi: 10.1109/SCES61914.2024.10652439.
[42] I. A. Alzuabidi, L. S. Jamil, A. A. Ahmed, S. A. M. Noah, and M. K. Hasan, "Hybrid Technique for Detecting Extremism in Arabic Social Media Texts," *Elektronika ir Elektrotechnika*, vol. 29, no. 5, pp. 70–78, 2023, doi: 10.5755/J02.EIE.34743.
[43] D. Masri, L. Jaber, R. Mashal, F. Albourini, M. A. Alsaoud, and A. M. A. Al-Tarawneh, "The Role of Wearables & Technology in Mental Health: Review," in *2nd International Conference on Cyber Resilience, ICCR 2024*, 2024. doi: 10.1109/ICCR61006.2024.10532880.
[44] M. Jawad *et al.*, "Physics-informed neural networks for rotating EMHD flow of Jeffrey hybrid nanofluid with arrhenius activation energy and mass convections," *Expert Syst Appl*, vol. 271, 2025, doi: 10.1016/j.eswa.2025.126517.
[45] A. Mansour, H. Al-Ahmed, A. Deek, K. Alshaketheep, B. Asfour, and M. Alshurideh, "Advancing Sustainable Practices in Electronic Customer Relationship Management," *International Review of Management and Marketing* , vol. 15, no. 1, pp. 1–8, 2025, doi: 10.32479/irmm.17346.
[46] T. Alkhrissat and S. Matarneh, "Impact of anaerobic co-digestion of ryegrass (RG) and cow manure (CM) on methane production and kinetic analysis," *Results in Engineering*, vol. 25, 2025, doi: 10.1016/j.rineng.2025.104028.
[47] A. Bin Naeem *et al.*, "Determine the Prevalence of Hepatitis B and C During Pregnancy by Using Machine Learning Algorithm," *International Journal of Intelligent Systems and Applications in Engineering*, vol. 12, no. 13s, pp. 744–751, 2024, [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85184920091&partnerID=40&md5=45c23c833c41256396d4f356aa6cb649
[48] A. Mughaid, I. Obeidat, L. Abualigah, S. Alzubi, M. S. Daoud, and H. Migdady, "Intelligent cybersecurity approach for data protection in cloud computing based Internet of Things," *Int J Inf Secur*, vol. 23, no. 3, pp. 2123–2137, 2024, doi: 10.1007/s10207-024-00832-0.