

NEST - Missing Child Tracking and Identifying Using Facial Recognition

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Abstract: A child going missing is a suffering past bearing not only for the parents and the child but for the entire community. The misery is a social hindrance that every government has tried to hitch up. There are various reasons that reinforce the computerization of a system. The chief among them is speed, accuracy, and efficiency. Machines with relevant data, fitting algorithms, and sufficient computational resources can satisfy user requirements much more effectively than the manual system with its tedious paperwork. Another prime reason is the scalability with the possibility to integrate all the subsystems involved. For a country like India, manual matching and monitoring each detail and data of a child missing is tedious if not impossible. The project titled Nest is an initiative aiming to help missing young ones find their loved ones back. Nest is an online web portal connecting Police Departments and NGOs across the country with a database to store the details of the missing and the found children, embedded with a facial recognition system to serve the purpose.

Keywords - Missing, child, facial recognition, lost, found, face, tracking, database.

I. INTRODUCTION

Facial recognition is an excellent medium to overcome the missing child or even person in general. We had a conversation with the pre-eminent entities of the story, the police department, the childcare NGO and the parents, and each of them welcomed the idea. The eminent frontline stakeholders endorse the idea and want to see it implemented as soon as possible.

Mr. Gyanendra Mishra, the president of UDAAN Society [1] a prestigious non-governmental organization working for the upliftment of the neglected communities explains the necessity of a nationwide database connecting the Child Protection Society/Units, Child Welfare Committees (CWCs), Child Care Institutions (CCIs), Police Departments, etc. with an example of a missing child from say Delhi found in Mumbai. Prolonged efforts are required from both sides, due to a lack of knowledge and data, which is obviously undesired. Face recognition systems will help us tide over; he adds.

Missing children is a serious concern for the government and all non-governmental organizations working for the betterment of childhood. Relative steps have been taken by governments in the past years. Databases store the missing children's complaints and respective details which give real-time updates to the users but in reality, it's nothing more than a storage system. For the current era, where a large number of children go missing every day, we require a robust and efficient system that not only stores the data but even helps in automating the process of searching children. To tackle such an important social problem, technological enforcement can help to boost the efficiency and pace of search for missing children.

II. LITERATURE SURVEY

A. Statistics

Multiple independent surveys by the Government and the non-governmental organizations have reported the number of missing children in India and the numbers are not very pleasing. As per the annual report "Crime in India" 2019 by the National Crime Records Bureau (NCRB), a total of 73,138 children were reported missing last year and the growth is exponential.

1. *Every eight minutes, a child goes missing in India.*[3]

7~8 in an hour, 180 in a day and 65,700 a year.

2. *~9% per annum increase.*[2]

In 2018, the total number of 67,134 children were reported missing and it had increased by 8.9% in 2019.

3. *World's second largest population and fourth longest railway network.* [4][5]

Railway Children an International Organization that creates a sustainable environment for children of the streets stated that every 5 minutes a child lands up unaccompanied on railway stations who might have run from home or lost from his/her parents.

4. *"Thousands of missing children kidnapped from India's railway network annually"* [6]

Sealdah Railway Station, Kolkata has one of the highest records of child abduction numbers. In 2015, the total child abduction record reached up to 41,893.[7]

5. *Lockdown- Covid and Children.*

On 24th March 2020, Prime Minister Modi had declared the first pandemic lockdown and since then till the lockdown upliftment up to 1 August 2020, there have been 3376 missing children's cases.[8]

B. Existing Databases

The majority of the police enforcements in India have their websites created for common people to avail information and features of online complaints, accident compensation, lost/found, and much more. Along with this they also have a missing person page. On this page, there is a photo and general information about the missing person. The database information is available only to the police enforcement of that province.

1) *Mumbai Police*

Along with the picture of the missing person, Mumbai police provides some essential details of the missing person such as Gender, Age, Place of Missing, description, the complaint registration no. and the corresponding police station on this webpage. With Direct call-line numbers to get in touch with the Mumbai City Police Control Room.[9]

2) *Maharashtra Police*

Some states have merged the database of the missing people in their state and made them available to the public. For example, Govt. of Maharashtra has a website made available for the citizens so that they can find the status of any missing person whose complaint has been registered in the police station inside Maharashtra.[10]

3) *Government of India – Khoya Paya Scheme*

Khoya-Paya Citizen's Corner for tracking children is a national-level government website wherein a person can register a complaint about a missing child or inform the whereabouts of a missing child. The website allows a person to view missing child complaints in any state. However, there are some restrictions on making a minor's image publicly available, so not all missing children's images would be available.[11][12]

4) *National Centre for Missing Children*

A non-governmental initiative for creation of a national database for missing children, but seems inoperative.[13]

The complaints of missing children are piling up on the law enforcement's desks and the resources available at their hands are very limited. Even if the government has launched various database systems that store the missing people and children's data, they still lack efficiency. It is a tedious and unpractical job for a person to cross-reference a missing child's image and data manually against their database. Not only this method is slow but it is subjected to human error as well. And for a country like India, with a very high population [4] and decently developed connectivity in terms of transport infrastructure, it turns out to be nearly impossible for monitoring and manually matching each missing person with each person found across the country.

C. The Eye-Opener Delhi Police Initiative

In the month of September, Delhi Police was given special permissions and resources help from the government. Delhi Police conducted a Facial Recognition Trial on around 45,000 missing children and out of the total children scanned 2,390 children could be identified between 6th to 10th April. The ministry later provided 7 lakh missing children's data along with their photos for the system.

The police traced 1440 missing children and in the same time period, 1222 children went missing.[16] The efficiency of the Facial Recognition System was quite good and its outcomes were amazing. The recovery rate for the above time period was 117.83%. With this achievement, Delhi Police received the backing of many organizations such as the National Commission for Protection and Child Rights (NCPR), Bachpan Bachao Andolan, Women and Child Development Ministry.

There have also been some cases where parents of the missing child do not report to the police station when the missing child had been found. This may complicate things for the police themselves who might waste their resources on finding the child when it already has been found.

Before the facial recognition system was implemented, the police officers themselves had to manually cross-reference the photo registered in the FIR and the photos of children who were found but were unaware of their place of residence or too young to speak. There were thousands of photos to be matched and this process would take weeks and months, till then more complaints would add up.

Delhi Police has also launched an android application for Missing Person Registration, thus, providing an ease for the citizens to report a missing person in no time from a handheld device.[14]

With so many missing children returned to their safe haven, it supports the need for more systems like the one Delhi Police has implemented. Although the achievements of Delhi Police's Facial Recognition System proved to be successful, there is still the problem of missing children. The solution to the problem of missing children is not to track them, but to prevent these tragedies and abduction/kidnapping from happening.

III. OBJECTIVES

- A nationwide database holding the details of the missing child complaint lodged and an unknown child found anywhere across the nation.
- To ensure usage restrictions with authentication and credentials provided to Police Departments and NGOs only.
- For any and every Image uploaded, a Facial Recognition Algorithm runs against it in the NEST server.
- Important details such as the gender and age of the child to help find matches more efficiently. The Scan and Match module to work in gradual progression in terms of area with respect to time.

For each image uploaded for a child missing or found, the scan and match module will be initiated and the facial recognition algorithm will run against all the images from the other table i.e., for a child missing all the pictures from the "found" table which are satisfying the condition, to converge the number of scans, for matching.

IV. PROJECT DEVELOPMENT MODEL

For NEST's software development we are opting for the SCRUM (AGILE) SDLC. It is very highly compatible with NEST. In this model, each sprint must be completed before the next sprint can begin and hence there is no overlapping in the development. NEST's software development moves forward with completion of each sprint and hence NEST thrives on this model. The SCRUM model is one of the widely used SDLC approach that was used for software development. [18]

Reasons for opting the SCRUM Model for NEST:

- Requirements for NEST were well known, clear and so all the objectives make up for the project plan.

- NEST's target users are law enforcement and NGOs however, the possibility of scaling of the system could be ensured by SCRUM.
- After completion of each sprint, there is no need for recursive planning and hence the model is suitable for the project.
- Once NEST is developed, we can proceed to add more features in future releases.

V. FEASIBILITY ANALYSIS

A. Technology and System Assessment

Facial Recognition Systems have come a long way in terms of accuracy and efficiency. There are many practical implementations in real life as well. For NEST's FRS, we came across - 'Dlib' [19] a python machine learning/deep learning library that had relatively good efficiency. After developing, training and testing the model, the results we obtained were pretty accurate. After some research by our project team members, we found out that Indian government has a nationwide database that stores the information of missing children. NEST needed to be a platform which would be fast and secure. Even though the FRS would take its own time, the delivery and scalability of NEST was also to be taken care of. Laravel a php framework satisfies all those needed conditions and can revoke the face recognition python scripts by shell. In addition to this, for the sake of the college project, there were no technological overheads present. When all these segments were researched and assessed further, the system was found potent.

B. Economic Viability

NEST has a high requirement for CPU processing speed for faster running of the facial recognition model for matching more children in less time. The complex computations for facial matching needs to be dealt with either with a faster algorithm or faster processing speed. Other than that, there is also the problem of a nationwide database consisting of missing children information. However, there is already a government database available for this purpose. Any collaboration with the party can majorly reduce the economic cost. In addition to that, since the project is for law enforcement and NGO usage, the database collaboration would be inevitable.

C. Social and Political Concerns

NEST is a powerful tool that automates the whole system instead of making a person work on their computers to manually match the two images physically. The information of the missing children stored in the system is private and hence is only limited to the police and government approved NGOs. This is because there might be a case of misuse of missing child's information against the child's family or the child itself. There is also the law that forbids making a minor's photo publicly available without court order/parental consent. To avoid those problems, NEST's availability is restricted to the law enforcement and the NGOs only.

VI. REQUIREMENT ANALYSIS

A. Hardware Requirements

- 1) *Processor:* Intel Core i3/i5
- 2) *RAM:*
 - a) *Minimum:* 2GB.
 - b) *Recommended:* 4GB
- 3) *Hard Disk:* 32 GB
- 4) *Additional Storage:* Incremental Device Storage for images with a minimum storage of 1 TB.

B. Software Requirements

- 1) *Operating System:* Windows, Linux, and macOS with a JavaScript-enabled browser.
- 2) *Frontend:* HTML, CSS, and JavaScript with Blade PHP templating boilerplate.
- 3) *Backend:* PHP-based Laravel framework with MySQL/MariaDB database.
- 4) *Software and Libraries:* Python 3.x, Dlib, Open-cv, SQL.
- 5) *Server:* AWS EC2 Instance and Local Host for Testing purpose.

C. Functional Requirements

- As proper and distinct possible pictures of missing children to be fed in the system by the user.
- Only Law Enforcements have the authority to register a missing child case.
- The system should keep a tab of new case registration and the finished search matches, and rerun the FRS query for the appropriate finished queries against the new cases.

D. Non-Functional Requirements

- No information of the missing child should be leaked from the system.
- Once a missing child is sent home, the FRS algorithm should stop for that instance and retain the information in logs.

E. Project Methodology

- For the project software development life cycle we chose, SCRUM methodology. The project has implemented various frameworks and libraries from domains of machine learning and web development.
- For the facial recognition system module of the NEST system, the Residual Network also known as the RESNET [20], a type of neural network model was implemented. It is one of the base modules of computer vision tasks. The model has the

lowest error rate and is relatively efficient. The model efficiently matches the missing children's images, and allows the police and NGOs to scan through the matches with highest accuracy.

- On the web development side, Laravel, a php framework was used. Laravel follows the Model-View-Controller (MVC) design pattern. The features of Laravel that facilitated the NEST system are Authentication, Schema and Query builder, Eloquent and CSRF protection.

VII. IMPLEMENTATION

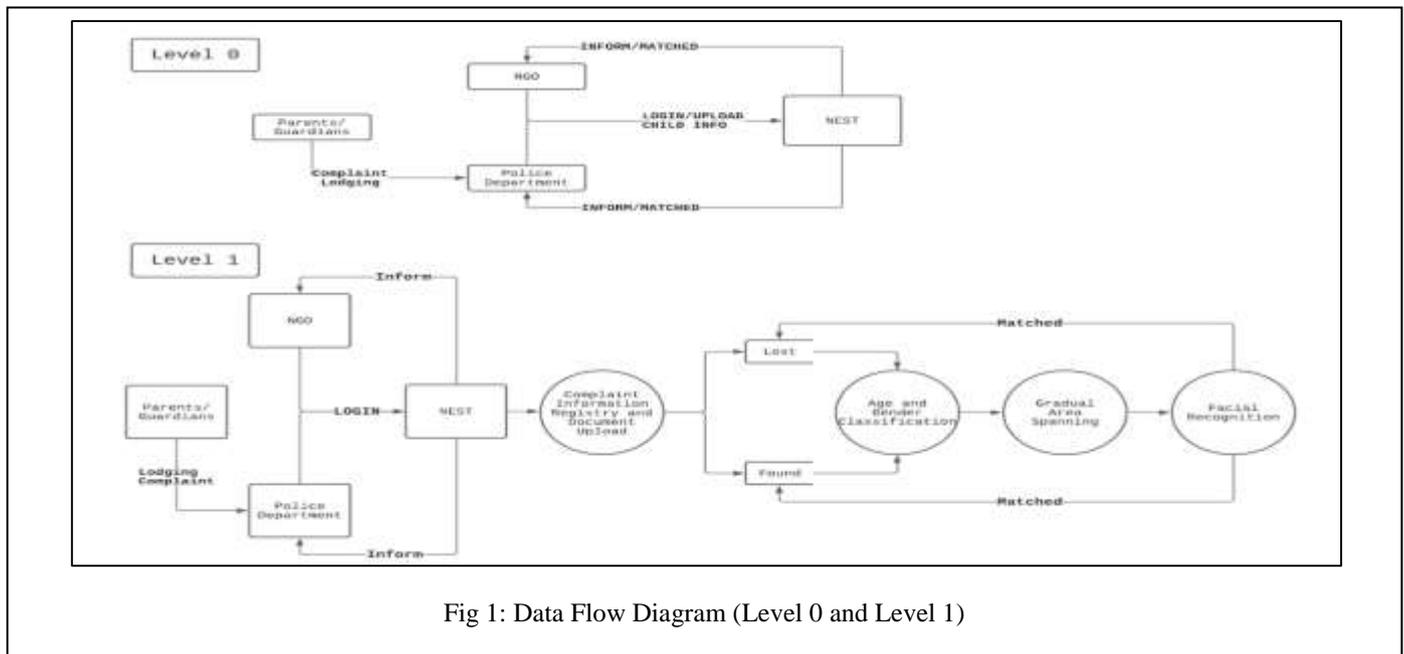


Fig 1: Data Flow Diagram (Level 0 and Level 1)

A. User Registration and Authentication

For the development of the system, Nest allows a user with a valid email address to register with a button click, but in actual use case implementation of the system, the registration of police departments and NGOs would be an internal affair provided to the admin. Also, Nest only allows Police departments and childcare NGOs to upload and get results from the system, but the system can be scaled for use by a common man after close analysis and thinking.

User Registration was implemented using Laravel Auth taking the name of the system user, location, address, and contact along with the station in charge and NGO's president respectively.

B. Registering a missing or found child

Access to a nationwide database to all the registered NGOs and the police stations with the ability to upload details along with pictures of the child missing and found. At the point of writing this report, we only let police departments add missing child reports to make sure the appropriate complaint was lodged whereas, for a child found, the corresponding details can be added by both the police and the NGO.

For each image uploaded for a child missing or found, the scan and match module will be initiated and the facial recognition algorithm will run against all the images from the other table i.e., for a child missing all the pictures from the "found" table which are satisfying the condition, to converge the number of scans, for matching.

C. Age and Gender

Age and Gender are two factors that would result in higher efficiency of the NEST system. Facial Recognition algorithms are quite complex and hence require a fast-processing platform to run. Hence it would shorten the burden on the CPU if we can avoid running the facial recognition scripts for certain instances. One way we avoid unnecessary running of facial recognition algorithms is by verifying the target's gender. If we are running a facial recognition script for a girl's image against the images stored in Found Table, practically we should not run the facial recognition script against a child of any gender other than female. This filtration alone decreases the need of running the scripts by almost half of the original numbers. Age is the other factor that will help us avoid the need of running unnecessary scripts. In the Nest system, we can get the missing child's age if a missing child's complaint is being registered by the complainants. However, it's not the same case when an unknown child is found at an NGO or Police. While registering the unknown child, the official person would have to approximately guess the missing child's age. Even though it is not possible to correctly guess a child's age, a guess can be made, with a tolerance of 5-7 years. Implementing this technique in NEST increases the efficiency of the system by almost two folds.

D. Time-defined Area Spanning

This factor helps in converging to a certain area range with the center of the range as the police station or NGO. Let's consider an example if a child missing complaint is lodged at a police station in Mumbai so the system technically should not check with the information acquired about a found child in Delhi at the very first time. So, for providing a priority to the neighboring regions and cities, an area spanning will be an efficient technique. For this, we provide two different techniques for an area spanning.

E. Age and Gender

NEST is a powerful tool that automates the whole system instead of making a person work on their computers to manually match the two images physically. The information of the missing children stored in the system is private and hence is only limited to the police and government approved NGOs. This is because there might be a case of misuse of missing child's information against the child's family or the child itself. There is also the law that forbids making a minor's photo publicly available without court order/parental consent. To avoid those problems, NEST's availability is restricted to the law enforcement and the NGOs only.

a) *Geocoding*: In this method, we capture the latitude and longitude of the last location of the child missing or the location the child was found. The latitude and longitude of the user can be retrieved using the Geolocation API [21] or the Geocoding API [22]. The Geolocation API asks the user for access to the location of the browser and then it retrieves the location using the best available functions such as the GPS. There is another way, using Laravel's composer package called "stevebauman/location". [23] It uses the IP address of the system to fetch the latitude and longitude of the user. The only disadvantage of this package is it is vulnerable to the use of VPN. Once the latitude and longitude are fetched, the system updates the area for searching over a certain time.

b) *Node Switching*: Distance Vector Routing algorithm is a dynamic routing algorithm in which each router maintains a vector, which gives the best-known distance to each destination and information about which path to be chosen. In our case, assume the routers to be Police Stations and NGO offices. Each police station has a vector that stores information of its nearest neighbors. Once all the stations and offices have their own vectors, a large-scale, nationwide graphical network is created. Say a missing child case is registered at a police station, a face recognition script is run against the Found table in the database for children found in that specific police station. If there is no match then the police station contacts its neighbors registered in its vectors. The lost child's image is then compared with the found children in the "found" table in the database, for children found in those neighboring stations and offices. This process continues and the network keeps on expanding till the whole network is covered.

The prime drawback of this method is it gets into an infinite loop because at each node the vector consists of neighbors. So, when traversing through the network, it will bounce back to the originating node. So, to avoid this problem a visited graph would be helpful where if a particular node is visited, the graph gets updated with that information and will check if the node is visited already while traversing in the network. Also, the system should check for any new upcoming cases at the visited nodes because this might miss out on the chances of matching the missing child case.

F. Face Recognition System

For NEST, we took up the facial encoding technique for our facial recognition algorithm. In this technique feature points or landmarks were plotted to capture salient facial features such as eyes, nose, chin, jawlines, eyebrows, etc. Higher the number of landmarks, more details of the features of the face would be encoded. For optimal performance for facial recognition around 60-80 points is recommended. For Nest, we plotted a total of 68 points for facial encodings.

The facial encoding process is set into motion once people's faces are detected and are saved afterward. These saved encodings are then used to compare against a target image's encoding. The comparison between these image's encodings is done by Euclidean distance. Based on certain differences in the distances, a certain threshold also called Confidence Value becomes a deciding factor whether the image's encoding matches or not. If the threshold value is too strict then even similar images might not match, on the other hand, if the value is too low, then even two images of different people might match.



Fig 2: Facial Encodings

VIII. DATABASES

The Nest database consists of 15 different tables are as follows:

1. *Users*: It consists of basic information of the user consisting of both police and NGO.
2. *Police*: The table includes additional information about the registered police station.
3. *NGOs*: It consists of additional information about the chairman or the person of responsibility for the NGO.
4. *Locations*: It includes the physical address of the user.
5. *Lost*: The table consists of the necessary details of the lost child as per the method the police department stores.
6. *Found*: Same as the lost table above, it also consists of important information about the found child such as the location, date of found, etc.
7. *Children*: It is an intermediate table between the lost table and found table for the ease of the system.

8. *Photographs*: It consists of the children's photographs for facial recognition and matching.
9. *Face_recognition*: It is a mapping table for storing the face match percentage of the checked candidates.
10. *Information*: It includes details of the child's outfit and some unique description of the child.
11. *Appearance*: The table consists of the lost or found children's physical appearance which can be helpful in further verification.
12. *Medical*: The table includes the medical history and medical description of the child.

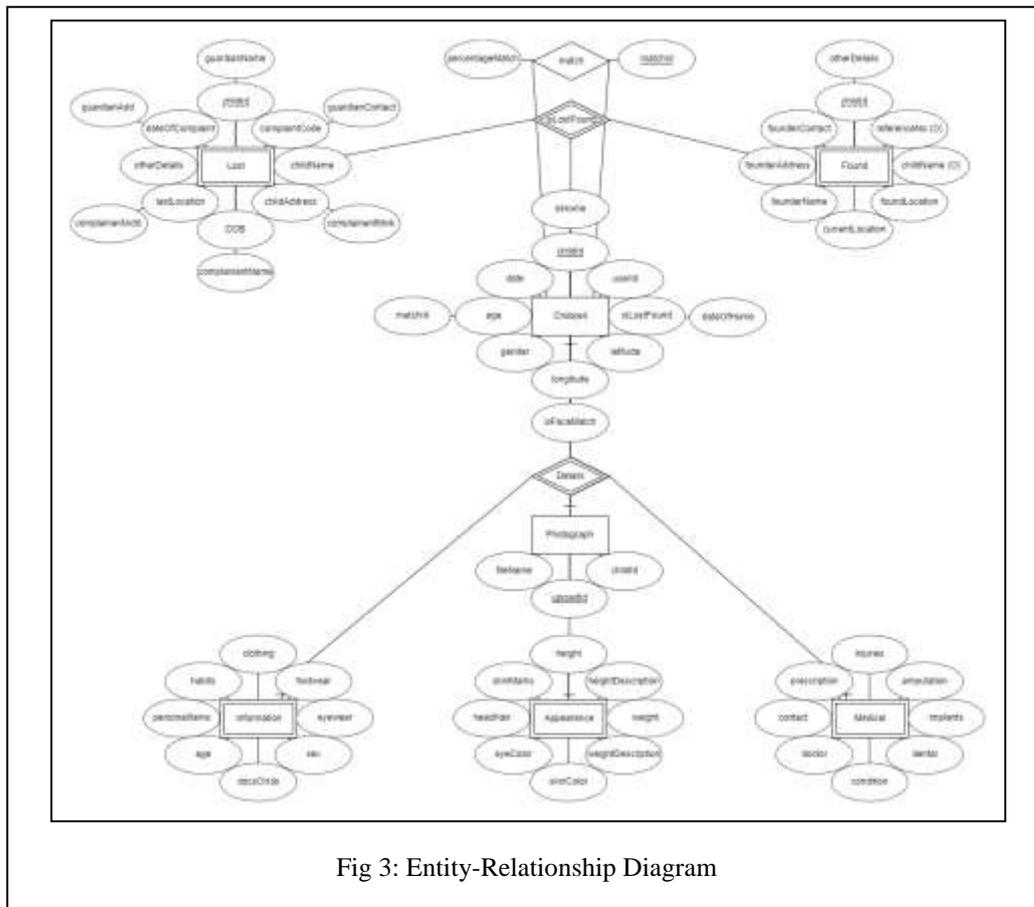


Fig 3: Entity-Relationship Diagram

IX.

ALGORITHM

Whenever there is a new entry into the database a python script is executed in the Nest system. Children, face recognition, and photographs are the database tables of concern for the program execution. For explanation purposes, we consider the input image of the new case as the base image.

1. In a new case added to the system, the child's images, age, gender, date, and location are stored.
2. Update the latitude and longitude by ± 2 .
3. Store the current time as the script will run for a time period of 15 days.
4. Consider a matrix or a dictionary that will store all the found cases if the original case was of a lost child or vice versa.
5. Use the face recognition model to detect the face, then compute the facial encodings of the base image with the images in the matrix.
6. On completion of facial matching of the base image with one of the sets of images in the matrix, store the value of the face match percentage in the facial recognition table as per the base image id and against image id.
7. After finishing all the images in the matrix, increment the time in terms of fractions and also update the latitude and longitude values with respect to time.
8. Check for the isHome value, if it's 1 then stop execution else continue.
9. Also, update the matrix with new cases in the new area range.
10. If there are no new cases in the updated area range then check for new cases after every hour has passed.
11. After completing 15 days, if the matrix is not empty i.e., new cases are pending then complete the face recognition process on those images and stop the execution for the base image.
12. If the base image got a match before 15 days, update the value of isHome to 1.

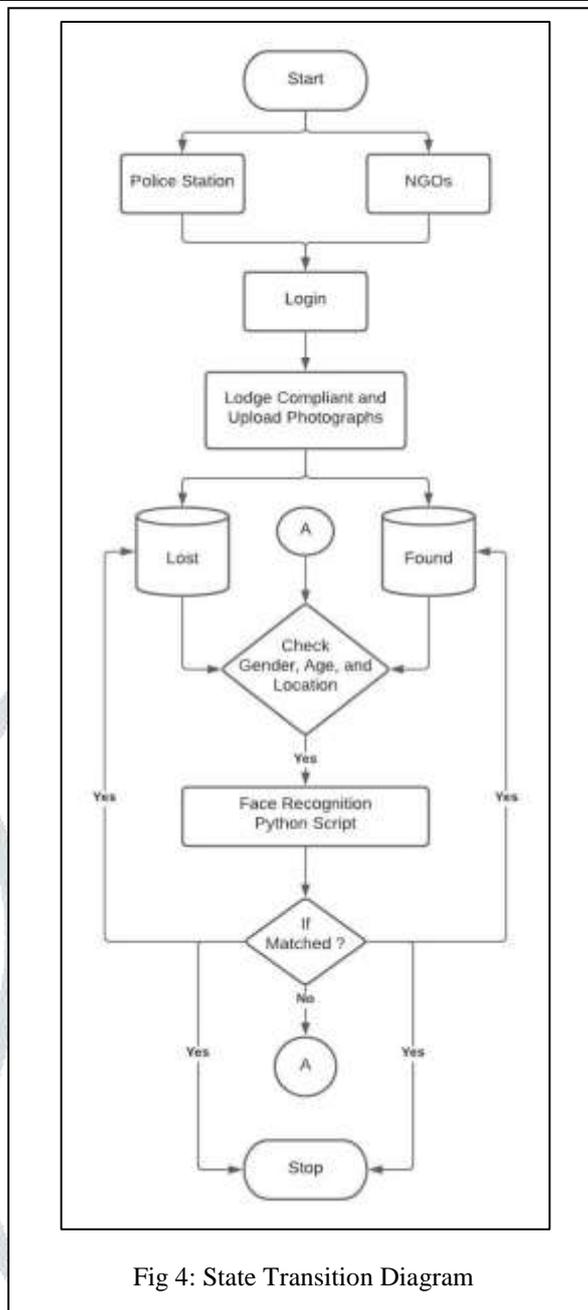


Fig 4: State Transition Diagram

X. GROWTH IN ACCURACY

When comparing between the encodings of two target images, the difference or the factor that distinguishes them is the Euclidean distance between them. This is the fundamental principle on which differences in images will be evaluated. However, even two pictures of the same person will have a certain Euclidean distance difference between them. So, if we train the model strictly (strict hyperparameters) and not over-train it on a dataset, chances are the model would not consider the two images to be of the same person. Hence the deciding factor that determines whether the two images are similar or not needs to be set appropriately so that the model is flexible for recognizing the slightly different images of the same person.

The deciding factor is called Confidence Value. After testing and tuning the hyperparameters, a confidence value between 0.45 and 0.6 would achieve practical growth in the accuracy of the system.

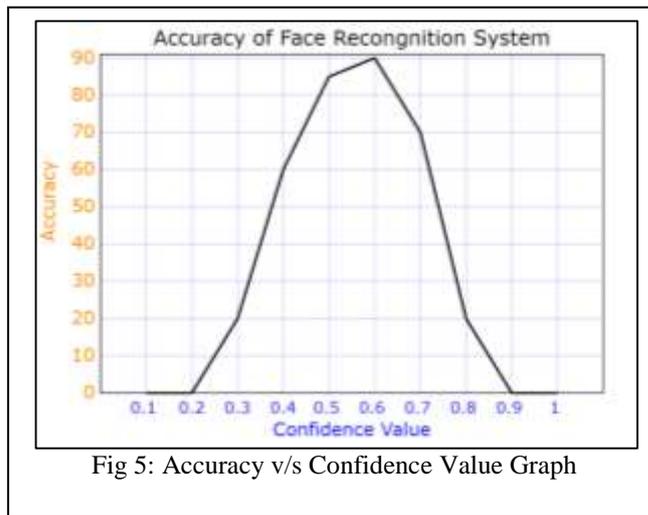


Fig 5: Accuracy v/s Confidence Value Graph

XI. RESULT

A. User Registration and Authentication

The only difference between the homepages of Police and NGO is the feature of registering a lost missing child. It is mandatory to register a missing child at a police station and not at an NGO. The homepage has a dashboard which contains the police stations or NGO’s profile details and it can be edited. The Lost and Found button redirects the user to their respective child registration forms. Below the dashboard we have the profiles of the missing children registered at that police station/NGO.

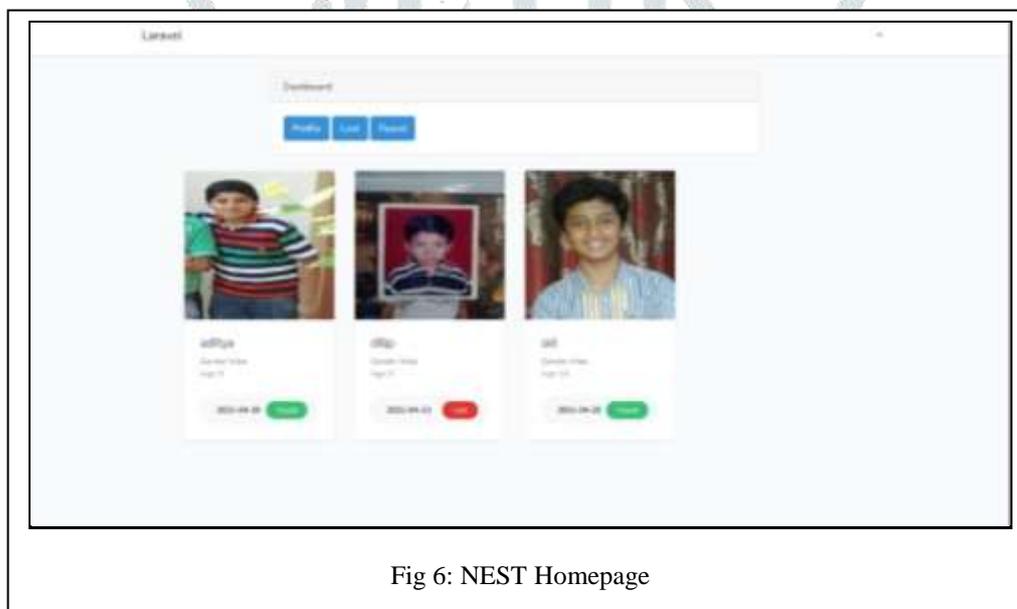


Fig 6: NEST Homepage



Fig 7: The matching of a child using NEST system with an accuracy of 67.66%

XII. A CONCLUSION

The rise in missing children is a serious problem, and affects both mentally and physically both the parents and the missing children. NEST is a guardian that makes sure that every unknown missing child is returned to its home. The NEST system is helpful to both the Police and the NGOs of the country, saving huge time and human resources. The nationwide database would keep the child record available to all law enforcements reaching out to all corners of the country. The NEST model is capable of matching the lost and missing children with excellent accuracy with the use of neural networks.

XIII. A FUTURE SCOPE

The project is currently being limited to children but can be scaled up to all categories of people with certain changes in the database and python script. The face recognition model used in the project is a Dlib's ResNet model which is a bit heavy for processing, so switching to a light face recognition model can be a choice in the future.

Age Progression [24] plays a vital role in facial recognition as it helps in facial matching when both the images belong to different time periods. Age progression is the process of predicting the future facial appearance of a person. To achieve better accuracy, family members' images can be used to produce an age-progressed facial image. In our system, NEST, age progression can be beneficial in improving the accuracy and increasing the chances of facial matching.

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