An Intelligent Traveling Companion For Visually Impaired Pedestrian

Richard F. Joseph
Dept. of Computer Engineering
Sardar Patel Institute of Technology
Mumbai, India
richard.spit2012@gmail.com

Anand A. Godbole
Dept. of Computer Engineering
Sardar Patel Institute of Technology
Mumbai, India
anandspce@yahoo.com

***Abstract*—A navigation system that will guide the blind and the visually impaired pedestrian with ease. The system will adapt to the user's behavior and will also provide the user with shortest path from the source to the user's chosen destination in the building. RFID technology is used to track the user's current location. The user carries his own PDA with the application installed in it and a RFID reader with him. RFID tags are deployed in the building. On detection of the RFID tag by the RFID reader as the reader comes in vicinity of the tag, the reader sends the tag information to the PDA using Bluetooth Technology. The PDA based user device provides the user navigation instructions in an audio form and the user can also select the preferences provides by giving input in form of speech. The system will be a blend of Optimal Routing and Users Preference. The PDA consist of the ACO algorithm that will help in the optimization of A* algorithm which will work as the prediction algorithm.**

Keywords—ACO; A* Algorithm; Adaptive; Evaporation; RFID; Weight Modifier

I. INTRODUCTION

Navigation is a very basic need of every individual. Every single person wants a way from the source to the destination that is safe, short, correct and free from obstacles. A person suffering from different disabilities such as visually impaired people have similar demands. Visually impaired people have to memorize each and every path, which is a very tedious task. They even cannot try out new paths as they lack the information about one.

Many systems are available in the market that supports outdoor navigation. These systems can interact with the visually impaired people by providing them with an output in form of audio and by taking input in the form of speech. The main technologies used in such systems are GIS, GPS, radar, ultrasonic, speech and RFID (Radio-Frequency Identification) technology. However, indoor navigation is restricted because of concrete walls as the GPS signals are blocked. Thus, GPS–based navigation system is no longer effective inside a building for the purpose of navigation.

RFID technology was taken into consideration to provide a solution for the problem associated with indoor navigation assistance. Meaningful placement of RFID tags in the indoor environment is very necessary to provide efficient navigation to the blind. RFID technology is a method for remotely storing and retrieving data using devices called RFID tags and RFID Readers. There are two different types of tags namely, passive and active. Passive RFID tags lacks built in power supply and the active one has its own power supply. RFID tags can be deployed in locations that are important to the user. For RFID tag placement research done by Wong Siew Mooi, Tan Chong Eng and Nurul Huda bt. Nik Zulkifli [11] will be used.

Basically, the RFID tags are installed on all the important locations that the user might go through and at regular intervals, so that the user keeps getting the location data along the way. RFID reader that can communicate with the tags along their way and can read the tags data. The reader can read the tag id. Each tag has unique ID. Each time an RFID tag is detected, the reader retrieves the location information from the tag and the blind user's position is known to the algorithm.

The proposed system will not only guide the visually impaired person but will also get adapted to the likes and dislikes of the person. The system will guide the user through a path which will be according to the user's preference. To do this the system will use the Ant Colony Optimization (ACO) Technique to optimize the prediction algorithm to predict the path with respect to the user's needs.

Each time the users uses the system, a prediction will be made for the user. If the user takes up the predicted path, the trial will be recorded as a success else as a failure. This result of prediction and the actual result will be fed to the ACO to optimize the inputs to the prediction algorithm.

Basic Bayesian Prediction will be used along with ACO. Different types of ACO will be used like Max – Min ACO and Rank Based ACO. This result of ACO will help change the weights of the path that is given to A* Algorithm. This will help the A* algorithm to give the shortest path.

II. RELATED WORK

Research has been done to provide navigation information to the blind and visually-impaired users [2-9]. Most of these systems cover a wide range of functions but the final output are inconvenient for daily use because they are heavy and complex [2, 3, 5-8] or are robot-assisted [4], which is not a feasible to the users.

Ali and Nordin [5] developed a system in which a camera attached to the cane identifies the surroundings for the blind person. While the proposed system has the disadvantages of requiring retrofitting of an existing aid for the blind along with leading to high response time.

Bourbakis [6] introduces a system equips the user with a microphone, camera, range sensors and earphone and combines outputs from cameras and range sensors (laser beams) to represent the 3-D space surrounding a blind person. The paper raises concerns about the battery life of 2-D vibrational arrays as well as replacing the laser sensors by other less dangerous sensors.

Fallah [7] develops the AudioNav system that uses a dead reckoning technique for indoor localization over a 3-D map of the building. The disadvantage of dead reckoning is that errors increase with time leading to high localization errors.

Chumkamon et al. [8] use RFID technology embedded in the floor along with a RFID antenna built–in the cane. Large response time to the client which is dominated by the communication delay with the server through the GPRS cellular network.

III. THE PROPOSED SYSTEM

As mentioned below, the system contains hardware and software. The hardware device works unidirectional in the range of 5-10 meters. This hardware is chosen to implement the concept of "Bring Your Own Device (BYOD)". These devices have been chosen because of these features which facilitate achieving the purpose of the system.

A. Components Of The System

1) Hardware Component

a) RFID Tags: The UHF RFID tags are deployed in the building. These tags have a unique ID and have an operating frequency of 433 Mhz, having a moderate data speed with a range of 1-100 m.

b) RFID Reader: The UHF RFID Reader is carried by the user along with the PDA. The reader detects the tags as the reader comes in the vicinity of the tags. The reader has an operating frequency of 433 Mhz, having a moderate data speed with a range of 1-100m.

c) Bluetooth Module: Bluetooth technology is integrated with the RFID reader to send the RFID tag id to the PDA on detection of RFID tag.

2) Software Component

a) Android Operating System: The application will be developed in android operating system as most of the people use android. Other operating systems can also be used, but looking at the popularity Android Jelly Beans 4.2 is used as the base for developing the application.

b) SQLite Database: SQLite 3.0 can be used as a database to store the details of the environment and the behavior of the user. The floor plan with all the details is also stored in the database. This database is installed in the PDA along with the application.

3) Objectives of the System:

- To provide the user with good response time.
- The device will have a better battery life as it is dependent on the PDA that the pedestrian uses.
- The user will get a handy device that will be small in size and easily portable.
- To provide the user with a device that will train it to adapt to user's needs and behavior.
- The input and output to the system will be in audio format.
- To enhance A* algorithm to provide the shortest route to the pedestrian along with the preferences of the pedestrian with the help of ACO algorithm.

B. System Architecture

The system architecture has the main component as Guiding System which has the algorithm that brings about a change in the inputs of A* algorithm with the help of the ACO algorithm.

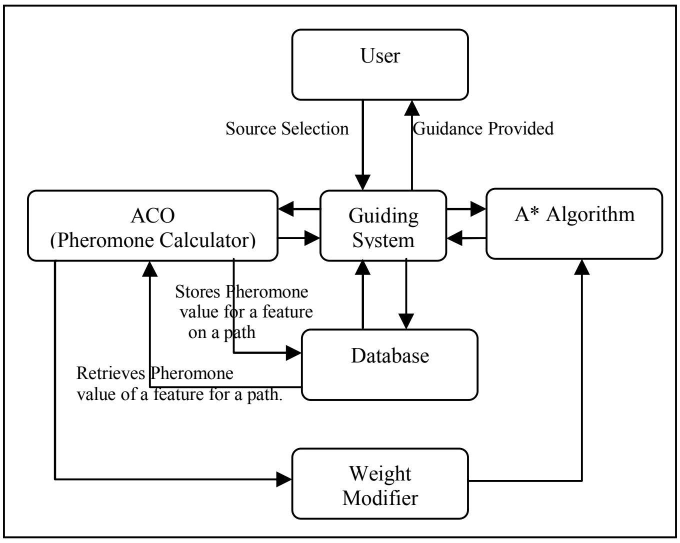

Fig. 1. System Architecture.

There are 6 important components in this system. The components are explained as follows:

1) User: The user only gives the destination and chooses the alternatives that are provided by the system. The user interacts with the system in audio format. The speech of the user is taken as input to the system and the guidance to the user is also provided by the means of audio.

2) Guiding System: The system gives the direction to the user for the path that is generated by the A* algorithm. The guiding system just navigates the user from one tag to another to reach the destination. The guiding system detects the tags in the path and is able to determine the current location of the user w.r.t. the path. The guiding system records the user's preference and the path taken by the user in the database.

3) Ant Colony Optimizer Module (Pheromone Calculator): The ACO module extracts the features from the path taken up by the user which is stored in the database. The research done by Samir ALLACH, Mohammad ESSAAIDI and Mohamed BEN AHMED [10] is taken as the base in this paper. The ACO module works on the success and the failure of the predicted path to allocate the pheromone to the particular feature. If a success is recorded in the database for a particular path then those features are given higher pheromone value. It just shows that the feature is repeatedly used by the user. If a failure is recorded in the database for a particular path then those features are given lower pheromone value. It just shows that the feature is not in use by the user for a long time.

The fact of evaporation of the natural pheromone over time is extremely important because it helps the ant colony to rely on the constantly updated information. In our artificial system, it helps the system to be globally dynamic than being locally static with the help of evaporation.

Each pedestrian who travels through the path on the floor plan (network) is represented as an "ant", a micro-agent. The ant releases pheromones. If the use is successfully validated, the pheromones will be those of success (S); otherwise, they will be of Failure (F). Therefore each path will carry, in addition to W (Weight of the Path), the two values S and F.

$$S_t = \tau^x S_{t-1} \tag{1}$$

Equation (1) gives the form of evaporation for the pheromones of success S (the equation is the same for F): t, the rate of evaporation, is a key parameter of the system. The period of evaporation x that says how often the evaporation is calculated is a constant learning. "x" can be taken in days and the value of "t" can range from 0 to 1.

The variable H (Personal History) belongs to each pedestrian, and bears information of traversed paths. Each time a path is validated, a history variable H, specific to pedestrian is created and stored in database and set to h1 = 0.5 if it is a success, to h2 = 0.75 if it is a failure. This value will be later used as multiplicative factor to reduce the probability to visit that node again. When it eventually happens, H is again multiplied by h1 or h2. Just like S and F, H evaporates and tends to go back to 1 with time, following:

$$H_t = H_{t-1}\left(1 + \frac{1 - H_{t-1}}{H_{t-1}} \frac{1 - e^{-\tau x}}{1 + e^{-\tau x}}\right) \tag{2}$$

Where τ is a constant used to tune the evaporation speed and $\varkappa$ is the amount of time elapsed since the last visit to that path. τ should be calibrated to correspond to the volatility of the pedestrian's memory:

$$\tau = \frac{1}{x}\ln\left(\frac{1+\alpha}{1-\alpha}\right) \tag{3}$$

With

$$\alpha = \frac{H_t - H_{t-1}}{1 - H_{t-1}} \tag{4}$$

Provided one defines what "forgetting the elements on the path" means, for instance if its H value, from $H_{t-1} = 0.5$ (one visit with success), grows back to $H_t = 0.9$, this gives $\alpha \approx 0.8$ and a team then only has to estimate the time it takes to "forget the elements on the path": one week for example (x = 604800sec.) gives $\tau = 3.6E-6$.

Fitness calculation takes place on each of the path in the network:

$$f(\alpha) = H.(\omega_1 W + \omega_2 S - \omega_3 F) \tag{5}$$

This value unifies in a weighted average all the factors that make a path "desirable" or not: f is high when:

- The path's ending node was last visited a long time ago (H is close to 1).
- The path is encouraged by user's choice (high W).
- People have succeeded a lot at a node (high S).
- People have failed a less around the path (low F)

4) A Algorithm:* A* algorithm works along the principle of heuristic and best path till the current node on the path. It traverses the network; it follows a path of the lowest expected total cost or distance, keeping a sorted priority queue of alternate path segments along the way. The cost function is a sum of two functions:

a) The past path-cost function: It is the known distance from the starting node to the current node x (usually denoted g(x)).

b) A future path-cost function: It is an admissible "heuristic estimate" of the distance from x to the goal (usually denoted h(x)).

The h(x) part of the f(x) must not overestimate the distance to the goal. Thus, for an application like routing, h(x) might represent the straight-line distance to the goal, since that is physically the smallest possible distance between any two nodes.

If the heuristic h satisfies the additional condition h(x) <= d(x, y) + h(y) for every path (x, y) of the network (where d denotes the length of that path), then his called monotone, or consistent. In such a case, A* can be implemented more efficiently—roughly speaking, no node needs to be processed more than once — and A* is equivalent to running Dijkstra's algorithm with the reduced cost d'(x, y) := d(x, y) - h(x) + h(y).

In this case, the weights (cost for going from one point to another) will change as per the inputs given by weight modifier. A* algorithm will ignore the path with higher weights (paths having low pheromone level). Research done by Ma Changxi, Diao Aixia, Chen Zhizhong and Qi Bo [1] is used in this paper to make the A* algorithm behave as the prediction algorithm.

5) Weights Modifier: The weights of the path having the particular feature are changed depending on the pheromone level of the featured assigned to it by the ACO. The Weight Modifier takes the data from the database related to the extracted features from the path chosen by the user. We have taken following features to be considered for user's choices that can result into weight modification of paths containing them.

- Elevators vs Stairs
- Crowded Lanes vs Deserted Lanes
- Wide Lanes vs Narrow Lanes
- Hand Rails vs Guard Rails

6) Database: The database consist of the following:

- Logs of the user.
- Floor plan.
- The feature location on the floor plan.
- The path taken by the user and the details.
- The count of features taken up by user.
- The weights of the paths.

C. Flow Of the Proposed System

In the flow of the proposed system consist of ACO algorithm and A* Algorithm. Here the ACO used is Rank Based ACO as it will always try and provide the user with all the preferences and also the shortest path.

The flow of the system presented in Fig. 2 shows the flow of the user when he uses the system and also the internal functioning of the system that the user is not aware of. The flow is explained as follows:

1) Initialization: All the paths in the building are initialized to infinity.

2) Destination selection: The user enters the destination using the voice input into the system.

3) Source detection: The source is not entered by the user. The source is automatically detected as soon as the RFID tag comes in proximity of the device.

4) A algorithm:* Shortest Path gets formulated from the source to the destination using the A* algorithm.

5) Feature presentation: The user is presented with all the key features of the path that the system feels are necessary for the user to know beforehand. These features are the parameters on which the user's preferences are evaluated.

6) User guidance: User is guided along the path with the help of RFID tags.

7) Providing alternatives: Throughout the path the user is suggested with alternatives that he can take up to reach the destination along with the key features of the alternatives.

8) Users decision: It is up to the user to take up the alternative

a) Alternative selected: If the user takes up the alternative.

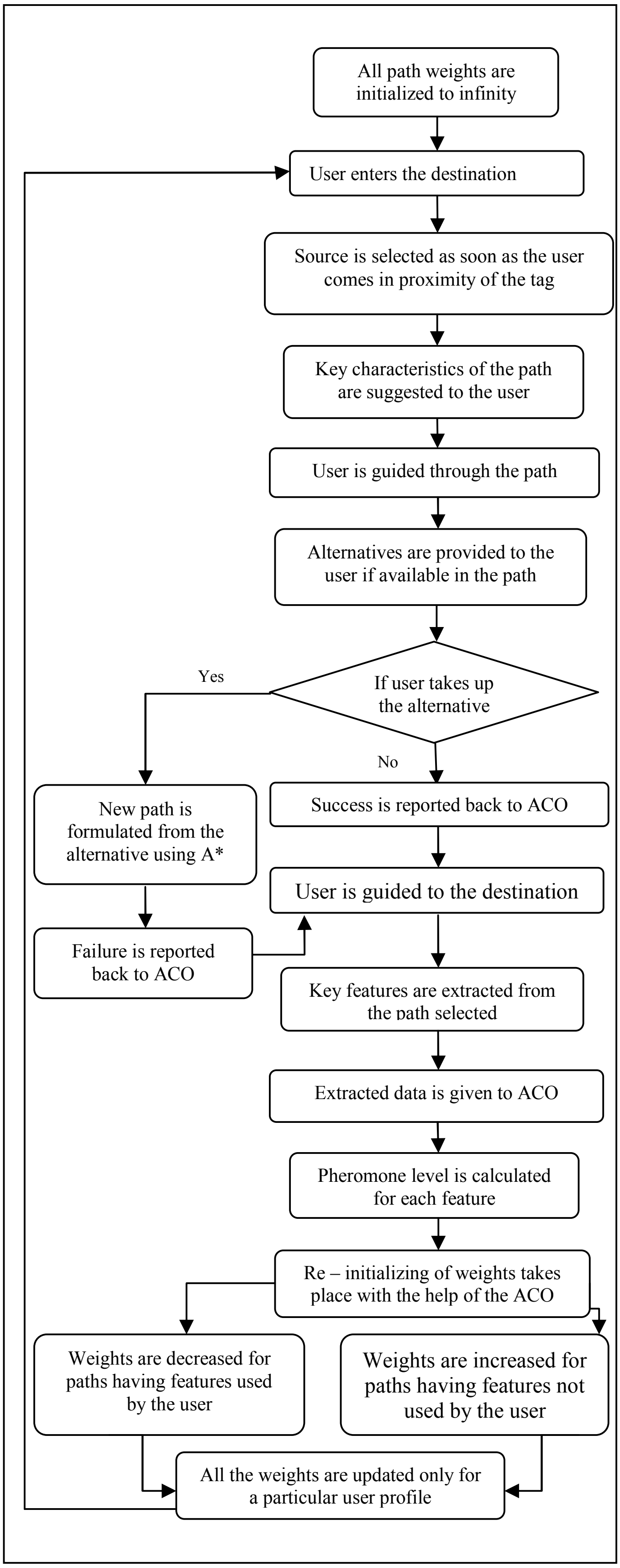

Fig. 2. Flow of the Proposed System.

- Dynamically a shortest path gets formulated from the alternative to destination using A* algorithm.
- Failure of the predicted path is given to the ACO algorithm for further improvements.

b) Alternative Rejected: If the user does not take up the alternative.

- Success of the predicted path is given to ACO algorithm for further improvements.

9) Reaching destination: User is guided to the destination.

10) Feature extraction: Key features are extracted from the path taken up by the user from source to destination.

11) Sending features to ACO algorithm: All the extracted features with result of the prediction are passed to the ACO algorithm.

12) ACO algorithm processing: ACO then calculates the pheromone level for each extracted feature. ACO algorithm gives higher pheromone value to features mostly taken up by the user.

13) Weight modification: Re – initialization of the weights takes place with the help of the output given by the ACO algorithm.

a) Weight decrement: Weights are decreased by a certain percentage for a path if the pheromone level for the features in that path is high. As pheromone level increases the weight decreases.

b) Weight increment: Weights are increased by a certain percentage for a path if the pheromone level for the features in that path is low. As pheromone level decreases the weight increases.

14) Saving user profile: All these weights are adjusted for a particular user profile.

15) Next iteration: The network with the new weights is used for the user during his next iteration, when the user selects the new destination and the entire process is repeated again.

The A* algorithm works as the predictor as it gives the path that suits the user's preferences. The algorithm is always provided with the same network but with different weights.

IV. TESTS AND EXPERIMENT

Simulations are made to obtain a comprehensive calibration of numerical parameters and to verify the system behavior in some particular cases.

In this simulation, we work on the data that is recorded for a particular user. The data is recorded for 50 instances at different times of a day and on different days.

A. Data of Simulation

Table – I shows the data recorded for each feature. The 5th column "Overall %" shows the percentage for each feature for all 50 instances i.e. for all the records from the time when the user used the system first. The 4th column "Pheromone %" shows the percentage for each feature with respect to success and failure. The percentage increase with the use of feature and decreases if the feature is not used

This particular data for 50 instances is recorded in the duration of 7 days. For this 50 instances when value of "x" (Evaporation Period) is taken as 2 days and "t" (Evaporation Rate) is taken as 0.5. Pheromone % is normally high if the feature is used recently i.e. within the evaporation period.

TABLE I. LOG FOR EACH PARAMETER

Parameters	Feature Provided (No of times): A	Opted For (No of Times): B	Pheromone %	Overall (A / B) * 100 %
Elevators	38	28	46.28	73.68
Stairs	42	4	32.67	9.52
Crowded Lanes	3	3	22.73	100.00
Deserted Lanes	14	2	8.34	14.29
Wide Lanes	27	5	37.26	18.52
Narrow Lanes	32	30	93.61	93.75
Hand Rails	46	21	84.12	45.65
Guard Lanes	3	1	2.46	33.33

The data in table – I presents us with the following observations:

1) Elevators: The percentage of use from the start is 73.68%, but the pheromone level is 46.28%. This shows that the particular user is not using the elevators recently.

2) Stairs: The percentage of use from the start is 9.52%, but the pheromone level is 32.67%. This shows that the particular user is using the stairs recently.

3) Crowded lanes: The percentage of use from the start is 100%, but the pheromone level is 22.73%. This shows that the particular user is not moving about in crowded lanes recently.

4) Deserted lanes: The percentage of use from the start is 14.29%, but the pheromone level is 8.34%. This data doesn't show anything significant as the particular user is not using the deserted lanes much.

5) Wide lanes: The percentage of use from the start is 18.52%, but the pheromone level is 37.26%. This shows that the particular user is using the wide lanes recently.

6) Narrow lanes: The percentage of use from the start is 93.75%, but the pheromone level is 93.61%. This shows that the particular user is using the narrow lanes regularly and recently.

7) Hand rails: The percentage of use from the start is 45.65%, but the pheromone level is 84.12%. This shows that the particular user is using the hand rails recently.

8) Guard rails: The percentage of use for guard rails from the start is 33.33%, but the pheromone level is 2.46%. This data clearly shows that the particular user is not using the guard rails much.

Weights of the paths containing these features decreases if the pheromone level increases and increases if pheromone level decreases. A simulation is done with the help of this data using PHP as the language and MySQL as the database.

In Fig. 3, the walls are represented in dark blue color, source is in green color and destination is in red color. Nodes that provide an alternative are represented as yellow and grey is used to show the path from source to destination. The suggested path that takes the users preferences under consideration is marked with alphabet "p". Alternatives are suggested to the user when the user reaches the yellow node. Alternative path are marked using notations like A1, A2, A3 and so forth. In Fig. 3, the user is suggested with a longer path as the user preferences are taken into consideration but the shorter path is also provided and suggested to the user in the form of audio, which is marked with "A1".

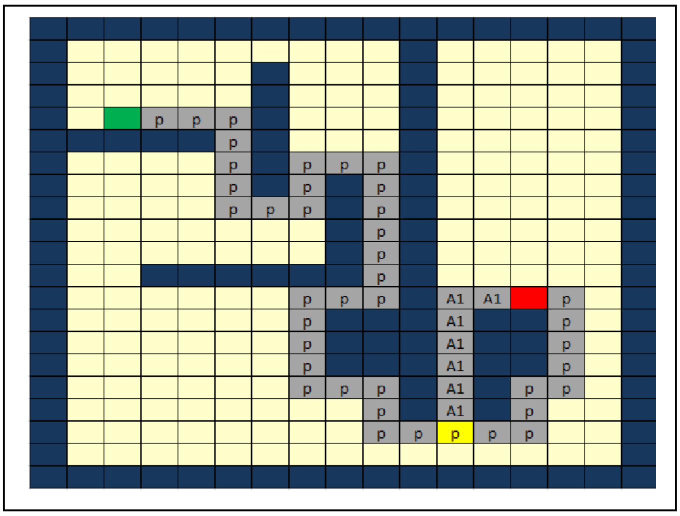

Fig. 3. Simulation of the Proposed System

If the user goes along the suggested path then the instance is noted as a success else as a failure. This result is given back to ACO for further optimization.

V. Conclusion

Hence the proposed system can adapt to the user's behavior and also provide the user with the shortest path to the destination. The system will provide the user with the following:

A. Response Time

Here the data will be stored in the Smartphone and all the computation will be done in the Smartphone, so the performance depends on the performance of the Smartphone.

B. Battery Life

This attribute is not of much concern as it is an application that will run on any android based Smart phone.

C. Size

A small product that will communicate with the Smart phone. This product has to be carried by the user everywhere he goes.

D. Adaptivity

The system will learn from the users behavior and will provide a route that is shorter and as well as suites the users behavior.

E. Communication

The system will work with I/O (input/output) in speech and hence will be interactive.

Future work will consist of work on I/O of the system which doesn't needs internet access. Currently the system uses Google API for speech recognition in android that needs internet connection.

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