U1 - The Ultimate Office Assistant with Artificial Intelligence

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Abstract— **Today, in places like offices, work stations and other similar places man power is normally used to move small objects such as files, documents etc from one place to another. It is a common issue that people make mistakes when they perform these tasks and it is human nature to forget the tasks that are assigned to them. This may lead to wastage of time. Security cameras are used to monitor places such as offices, workstations, shops etc. But the drawback of these security cameras is that they can only monitor a limited area. Therefore, there is no way to examine the areas which are out of the limit covered by the security cameras. Since there is no solution for the above mentioned problems the research is going to come up with a solution. "U1- The Ultimate Office Assistant with Artificial Intelligence" is a moving device which can monitor the areas which cannot be covered by the security cameras in a periodic manner or at given time periods and it can be used as an automated file transfer within an office. In addition to that, U1 is developed to respond to small voice commands and to generate warning alerts in case of an emergency such as fire using image processing concepts and inbuilt sensors. U1 is also able to track a particular colour and follow it. It also incorporates face detection and recognition for security purposes. These functions went through a series of tests which included unit tests, integration tests, system tests and acceptance tests. The accuracy rate of the system turned out to be 95% approximately. This study is helpful for the researchers who are interested in artificial intelligence and image processing to design and develop similar models or to develop the same device further. This concept can be used and integrated with other hi-tech automation projects.**

Keywords— **Artificial Intelligence, Image Processing, Automation, Voice Recognition, Office Automation, Face Detection, Face Recognition, Colour Tracking**

I. INTRODUCTION

The level of automation is very low in office environments both in Sri Lanka and in other countries, Man power and human involvement are still used widely in such environments to perform administrative tasks.

A. Research Problem to be Addressed

Clerks or peons are used to move small things from one place to another in an office environment such as carrying a set of files from one cabin to another. When doing so it is human nature to make mistakes and deliver the wrong files to a wrong destination. It is also common for labourers to forget tasks that have been scheduled for them. This can delay the business process and affect the outcomes of the business negatively. Wastage of time is identified as a critical problem in the current manual process of the above mentioned situation.

Surveillance cameras are currently used for security purposes in office environments. Despite the fact that there are high tech security cameras to monitor, there is always a constraint in the area that the camera can monitor.
CCTV camera systems cannot monitor every area of your office at all times. Hence it cannot be considered as a foolproof method for crime prevention [1]. There is always a question as to how far and wide the security cameras can see. How far a camera will see depends on the size of the lens and the width a security system camera will see is based on two things – The image sensor and more importantly the lens [2]. Fig. 1. shows how the camera vision works. There are also situations where surveillance is required only at specific times and therefore continuous monitoring is a waste of resource.

Thus, U1 which is developed will address the above mentioned problems and help people to transfer small objects quickly, efficiently in an office environment and also to customize their needs of surveillance for security purposes.

B. Background Context

Automation is the use of machines, control systems and information technologies to optimize productivity in the production of goods and delivery of services. The real incentive for applying automation is to increase productivity, and/or quality beyond the possibility within current human labour levels so as to realize economies of scale, and realize predictable quality levels [3].

A technology revolution is fast replacing human beings with machines in virtually every sector and industry in the global economy. More than 800 million human beings are now unemployed or underemployed in the world. That figure is likely to rise sharply between now and the turns of the century as millions of new entrants into the workforce finding themselves without jobs [4].

Today, in places like offices, work stations and other large places man power is normally used to move small

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things from place to place. Example: Peon who carries a set of files from one cabin to another in an office. It is human nature to make mistakes and forget tasks that have been allocated to them. This may lead to wastage of time.

Another problem which exists in such places is that despite the fact that there are high tech security cameras to monitor places, there is always a limit in the area that the camera can monitor. Not all paths and places in an office is 100% covered by the security camera.

Fig. 1. CCTV Camera Vision

An Ultimate Office Assistant with Artificial Intelligence is the proposed system for the above mentioned problem and will be called as U1 throughout the document. The system is comprised of an automated device which could go in specific paths that the user inputs. The device is programmed to sense objects in its path and take its own decision without human involvement. Apart from that, the device would also act as a surveillance camera in a particular location that the user wishes to monitor and also include functionalities such as fire detection and warning systems. U1 is also able to track a colour and follow it with voice recognition functions integrated in it.

Developing the proposed system – U1 in an office environment will lead to the following benefits:

- The need of an additional labourer is eliminated. This helps the business in saving time, reducing costs and boosting performance by increasing productivity. A study found that:
  - ✓ 83 percent of enterprises said automation delivered time savings;
  - ✓ 73 percent cited 'improved business productivity' as the key benefit of automation; and
  - ✓ 63 percent said automation regularly provides cost savings [5].
- Surveillance and monitoring of paths and areas in a specific location can be carried out with a moving device where as a normal CCTV security camera fixed in a permanent location cannot achieve. Monitoring is customizable and therefore helps to reduce resource wastage. A study found out that having only a subset of devices activated at any given time [6] is one way to conserve resource (such as energy) usage.
- According to Marshall Brain, founder of How Stuff Works and author of Robotic Nation, by 2013 there will be 1.2 million industrial robots working worldwide — that's one robot for every 5,000 people [7]. This is because automated process is now preferred over manual process by companies and individuals. It is attractive to watch an automated device performing errands as mentioned above in an office environment. Some people prefer interaction with robots rather than with human beings.

The objective behind the project is to implement a desktop system with an automated device which can act as a file transferring clerk and a mobile security camera with reliability, efficiency and user friendliness in an office environment limited to one particular floor in a building. Fig. 2. shows the high level system overview. The specific objectives include automation of file transfer within an office environment, surveillance and monitoring of specified paths at given times, respond to simple voice commands and automated decision making using image processing techniques and inbuilt sensors.

However this research project was not a very easy task from its beginning. There were lots of questions for the team to be solved throughout the research project. The main question was how will the device identify the path and move from one place to another place, in a particular floor of an office?

C. Research Gap

Though there are many autonomous robots for many purposes, in Sri Lanka there are no automated devices to transfer small things like files in an office environment, and also to surveil the places that cannot be monitored by a security camera due to its limited vision area. U1 will be targeting to fill this gap.

Since Sri Lanka is a developing country, this project will be a huge improvement and also will be an inspiration to other researchers who have similar interests on this research area.

II. LITERATURE REVIEW

In recent years a great deal of time and effort have been spent on developing systems to enable an autonomous robot [8, 9] to follow a marked path using a vision system. For this task, high performance computers can be used to perform complex image processing [10] and, typically, to maintain a mathematical model of the vehicle and the environment. Research into autonomous driving typically follows one of two approaches. In the first approach a mathematical model of the vehicle and its surroundings are generated, tested in simulation, and then applied to a robot. In the second approach a combination of a visual servoing [11] system and a kinematic model [4, 12] is used.

The following sections contain a brief overview of the research done in path following, including autonomous driving, and the research in visual servoing that can be applied to path following for autonomous robots.

A. Path Following

Path following research can be separated into two main categories: research involving road vehicles and research involving smaller robots. The following sections give a brief overview of the research in both categories.

1) Road Vehicles

Due to the large cargo spaces available in the vehicles considerable processing resources can be applied to the path following problem, thus path following techniques using real road vehicles tend to use complex processing algorithms.

While most of these systems use visual data as inputs, several other sensors, including range finders and odometers, provide additional feedback about the vehicle and the surrounding environment. Some systems are even capable of functioning, when an accurate model of the environment is given, only using range finding or location data.

The sensor data is then fed into the control system of the vehicle where most of the processing takes place. Typically the control systems are designed by Artificial Intelligence researchers and are thus based on systems such as Neural Networks [13], internal mathematical models or Fuzzy Logic [14]. Hybrid solutions have also been trialled, combining, for example, Neural Networks and reinforcement learning.

As the control systems use established techniques, much of the research concentrates on high-level processing, identifying stop lights and intersections, rather than on the actual driving.

2) Smaller Robots

As the size of these robots prohibit the use of high performance computational equipment, the algorithms [15, 16] used for path following are simpler than those used in the full sized road vehicles. However, in most parts, the same basic approaches are used though there is a greater emphasis on simulation.

The image processing steps for these robots typically use Kalman filters [17] and other simple functions for extracting information about the curvature of the path. The control system is typically a fuzzy logic system if one exists; see the next section, a kinematic model of the vehicle is also used.

Systems using learning techniques to locate the path need high performance computers, other devices and also must be trained in the actual environment under the full range of expected lighting conditions, an expensive and time consuming process. A robotic system which uses a model of the environment not only requires considerable time and effort to setup, it also requires the same effort whenever the environment changes.

U1 - The Ultimate Office Assistant with Artificial Intelligence was developed under this category for a floor of an office assuming that the floor environment will never change in future.

These kinds of robots have been developed in many countries as well as in Sri Lanka too such as from University of Moratuwa [18] and Colombo. These robots can be used for many purposes:

- To guide disabled people - able to guide the disabled people to where they want to go and also can notify them about the obstacles on the path [19, 20].
- Fire fighting - able to autonomously navigate a maze, locate a flame and extinguish the flame [21-23].
- To carry things in a supermarket - able to carry things that are going to be purchased by the customers of a supermarket. This will ease the work of a customer and no need to push the shopping trolley anymore [24].
- To follow a specific path - able to follow a particular path which is marked on the floor using image processing [25-30]. Fig. 3. shows a similar robot.
- For security and defence - able to detect land mines and also used in war or such situations to explore opponents' places where soldiers or security officers cannot reach directly [31, 32].

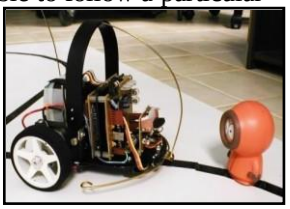

Fig. 3. Path Following Robot

- To care babies and elders - able to look after babies, small children as well as elders [33].
- Receptionist - able to respond to customers' questions and other clarifications of a particular office or a hotel [34].
- Virtual pets - these are used for entertainment purposes where these robots can act like real pets [35].

III. METHODOLOGY

For the development of U1, the System Development Life Cycle (SDLC) concept was adopted [36]. A wide variety of frameworks has evolved over the years, each with its own recognized strengths and weaknesses. Each of the available methodologies is best suited to specific kinds of projects, based on various technical, organizational, project and team considerations [37]. For the development of U1, the development team decided to choose Rapid Application Development Design (RAD) as methodology. Under RAD the project team followed Prototype as the sub methodology.

A. Planning

In this phase, project team identified why U1 should be built and determined how the project team will continue building it. The whole idea of the project and the value that can be gained by using this system were identified. The basic functionalities that are expected from U1 were also clearly defined. All project members involved in this process. Feasibility analysis helped to identify the risks associated with the project and determined whether to proceed with the project. Technical feasibility was carried out to identify the risks associated with the familiarity of the system, technology and the overall project size of U1. Financial feasibility was performed in order to identify the benefits associated with U1 and the total cost of developing this. Organizational feasibility was carried out to identify how well the system will be accepted ultimately by its users. This information was gathered using questionnaires and observations. A dynamic schedule of all tasks that need to be accomplished over the life of the project was prepared. Therefore the overall objectives of the system were listed and all the tasks that need to be accomplished to achieve these objectives were identified. Once tasks were identified the estimated time needed to complete these tasks were calculated. Each member was assigned to work and develop at least one function of the system. Apart from that, based on the skills they possess tasks were allocated to them. Until the finish of the research, controlling and direction of the project was handled by the leader. This was carried out by tracking tasks, refining estimates, motivating other members ensuring that everything happened according to the schedule. A project plan in the form of Gantt chart was prepared and used as a measure of control and direction.

B. Analysis

In this stage the current manual system was identified, how they operate, their strengths and weaknesses and came

up with a solution that is the proposed system – U1. Information gathering was done through observation of the office environment, referring to similar previous researches and also gathering data through questionnaires. Process modelling was done using a common technique called Data Flow Diagramming illustrating the activities of U1 and the movement of data in the form of a diagram. A data model was prepared which described how data of the proposed system was represented and accessed. This was represented using an Entity Relationship Diagram.

C. Design

In this stage, the system was developed from scratch and the skills of the team members were used to come up with their own system interface and functions to suite the requirements. In architecture design the plan for the hardware, software and communication infrastructure for U1 was performed. This system was server-based and therefore would rely on one server computer to support the processing of the new application. A network model was developed to show how the system and device will be located and connected to each other. A detail hardware and software requirements were identified. A security plan was designed to address how to keep U1 and its data secure. An automated door was developed in the model for the compartment where the items are kept. This can only be opened if the user is verified after a face recognition process. This addresses the security issue.

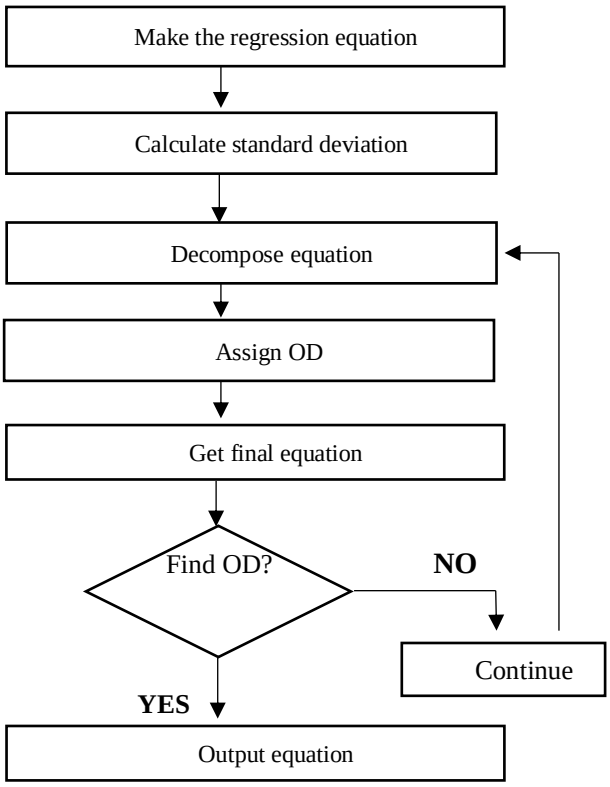

Figure 2:system flow

The architecture of the hardware components inside the U1 Device and how they are connected are shown in Fig. 4.

- Arduino Mega 2560 R3 - This is the mother board which processes the commands and communicates with other hardware peripherals.
- Motor Drive - This module is responsible to control the speed and spinning direction of the dc motor.
- Wi-Fi Module - U1 uses wireless communication to communicate with the server. Therefore this module shows and receives data through air using radio frequency.
- Ultrasonic Sensor - This is a distance measuring sensor. Using these module obstacles can be detected.
- DC Motor - To move U1 from place to place, four DC motors (4WD) are used.
- Battery - To power up the hardware modules battery pack is essential since U1 doesn't use any wired connections.

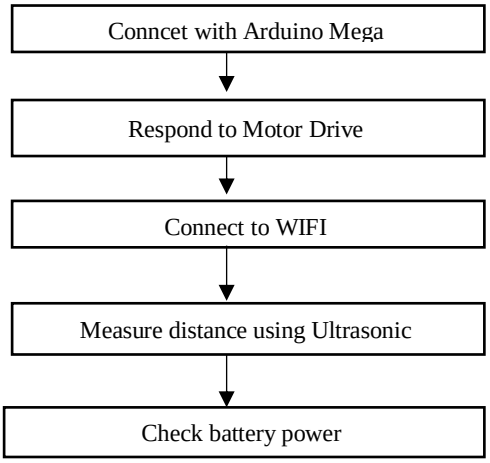

Figure 3:Architecture flow

The team defined the way in which the user will interact with the system and the nature of the inputs and outputs that the system accepts and produces. The interface was created in such a way where data is captured at source and minimizes key stroke. Database and file design were done where the tables were created in the system along with the primary keys and relevant validations and constraints. The database was linked with the application developed. Queries which need to be run in the system were developed. In program design the team produced pieces of code and worked together to form a program. The top-down modular approach was adopted and structure chart was used as a technique to show all components of code must be included in a program at a higher level.

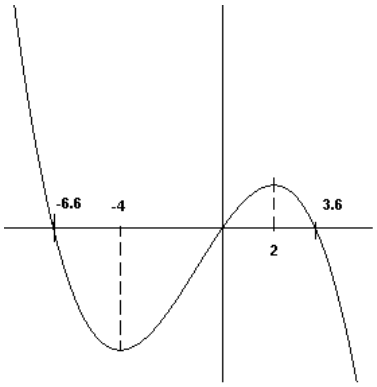

Fig. 4: Learning Curve

D. Implementation

Here what the project team did was the transformation of the design output into programs that are executable. Fig. 5. Shows the completed final model of U1. In construction stage, actual programming took place in this stage based on modules produced from the previous stage. Modules were assigned to different programmers. Once programming was completed, testing was done systematically and the results were documented. The system was developed using C# language. The following software tools were used to develop the system: ▪ Operating system: Windows 7

- Microsoft Visual Studio 2012: Required for C# programming.
- Arduino IDE: Microcontroller programming
- OpenCV and EmguCV : Required for image processing
- Microsoft .Net Framework 4.0: Required since the system is developed for .Net platforms.
- Microsoft SQL Server 2008: Required to maintain the database.

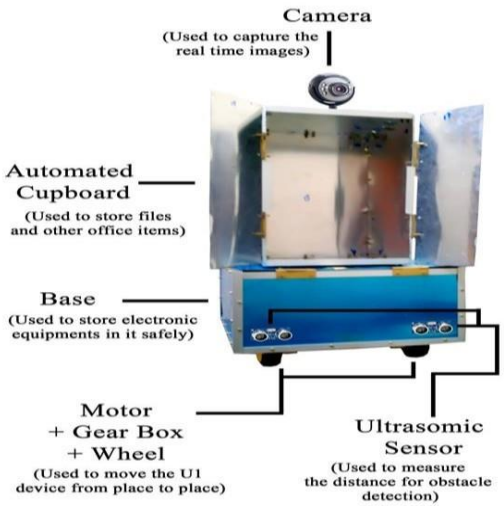

Fig. 4. U1 Device

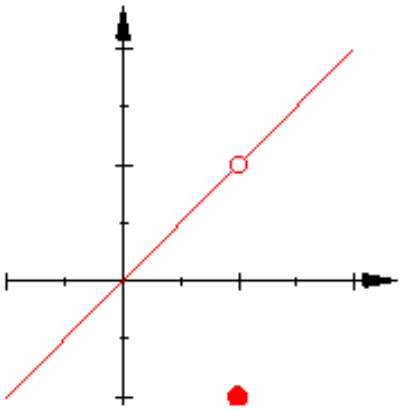

Fig. 5: Ultrasonic sensor

A test plan was developed which defined a series of tests that were conducted. Then the documentation was done where the final report has to be prepared. Since the team expected to build the system until the prototype level, there was no installation phase involved.

IV. RESULTS AND DISCUSSION

This chapter covers the results that were achieved from the research project and what were the new approaches found to address further research in the undergraduate context.

A. Research Findings

This section includes the research findings that the team was able to gather during the research project. This composed with constraints that the team had to face within the parameters of knowledge, time and local standards. The findings here are a stepping stone to a more advanced research.

The research team managed to come up with an algorithm to process an image of a floor plan with predefined formats and scales. This algorithm was used to extract path details from such as the distance from one cabin to another cabin in an office using pixels. This data will later be used to move the U1 device.

The team also came up with another algorithm to detect obstacles while the device is moving. This was developed with the help of predefined libraries to obtain ultra-sonic sensor data.

The ultimate aim of the research is to move the device from one location to another avoiding obstacles based on the data extracted from the floor plan using image processing. The team developed an algorithm to perform this task by experimenting different input values for the trigger of the motor. It was found that approximately for each trigger the U1 device would move 30cms.

When the system is delivering the documents to the specified users, the system has to ensure that the document is delivered only to the authorized person. For this process some kind of verification is required. The formal way to do this is by checking the username and the password. But it was found that, it also takes some time of the office people. Therefore the team came up with a solution where the specified users can simply face the U1 camera in order to prove their identity and receive their file. This way is

effective, easy and time saving. For this face detection and face recognition were used. Firstly, the system will detect whether there is a person in front of it and then recognize the face and check whether that person is the authorized person. As a special code segment the Capture class is used to represent the results from a single successful sub expression capture. In the following coding, the image is captured and converted it to the bitmap image. This helps to find rectangular regions in the given image that are likely to contain objects where the cascade has been trained for and returns those regions as a sequence of rectangles. The predefined libraries which are used in reference [38-40] were used to develop the system.

U1 device was also supposed to track a particular object and follow it when required based on a colour since tracking objects based on colours is one of the quickest and efficient methods of tracking an object from one image frame to the next. RGB filter was used to detect particular colour object. It will remove all objects in the image except the particular colour. The RGB filter is set to filter out particular object using an RGB colour channel subtraction and then normalize the remaining values. This will highlight the particular object clearly. The following piece of algorithm does the above mentioned. The predefined libraries which are used in reference [41, 42] were used to develop the system.

Even though the team developed this U1 concept for an office environment, in the midst of the research it was found out that this concept can also be used in other situations and for purposes such as:

- U1 device can be used as a carrier for the handicap or elderly people to carry their belongings from place to place.
- U1 can work as a medicine distributor in a hospital and distribute medicine to the patients at specified time periods.
- This device can be used in primary schools or kindergarten to distribute stationeries and toys to kids at each desk.
- U1 can be further developed to work as a Virtual Librarian who carries books within the library.
- This device can also be used as an automated trolley which can be used by the shoppers to follow them.

B. Evidence

Software testing was done to identify the correctness, completeness, and quality of developed computer software and to check whether the actual results match the expected results and to ensure that the software system is defect free. Unit tests were carried out to ensure that the module or program functions as defined in the specification. Integration tests were carried out to assess whether a set of modules or programs work together without error. System tests were performed to ensure the efficiency of all the modules and programs. Acceptance tests were performed in order to make sure the system is complete and meet the need to increase the efficiency.

The actual results of the tests were same as the expected results in most test cases. However, results showed that the device didn't travel the exact calculated distance in a path due to the weakening battery power. It was also found that the device failed to detect obstacles at certain angles while making a turn and therefore collided with the obstacle. This was due to the limitation of ultrasonic sensors.

95% of the tests were successful and the rest failed due to certain constraints mentioned below.

C. Discussion

This section reveals the failures and attempted technologies that were used during the period of the developmental stage of the proposed research system. During the developmental phases of the system the team used various approaches to handle the complexities of the proposed system development. In the initial stage of the research the team decided to use Java language since there were less tutorials and help on image processing and Arduino integration this proposal was given up due to the limited time the team had.

Though U1 completed its file transferring process succesfully the destination was not 100% accurate when analyzed the distance it travelled. The main reason for this was due to the constraint of low battery power which would affect the motor speed which in turn would affect the distance travelled. This issue can be solved if there is a way to maintain constant battery power.

Another problem that the team came across in the process of obstacle detection was, the obstacles U1 would encounter during turn being not detected. The reason for this problem was that the two ultra-sonic sensors are positioned in such a way that their range of capturing data does not cover certain areas during the turn. Fixing more sensors in different angles could be a solution for this problem.

In the testing process for the face recognition and face detection, in some cases the team did not get the actual output as they expected. In most cases the system was unable to detect the faces which are in front of its camera. The team tested the system in different aspects to detect this fault and finally found that, mainly it occurs due to poor lighting conditions and dark backgrounds. Therefore in order to get accurate output, it is required to have good lightning conditions with an appropriate background.

In the case of colour tracking the team did not get the actual output because if there is slight change in colour U1 might not get the exact colour what was predefined. The team tested this function in different test cases. For this colour tracking function the device will follow the object only with a particular colour which is predefined.

Finally the voice recognition function was not fully successful since it gave only a 60% positive result when tested. The sole reason for this problem is noise which is unavoidable. However if the environment in which this device is operated is of less noise the voice recognition function would work without any problem.

V. CONCLUSION

There is no doubt that Sri Lanka is still a developing country based on Automation. So by developing "U1 - The Ultimate Office Assistant with Artificial Intelligence" the team determined to automate the office environment and provide some benefits.

The project's main expectation is to complete the system with a high level of accuracy and with successfully completed system requirements, in order to save time and achieve efficiency. The completion of the system was anticipated to go on within scheduled time frames. The time frame needed to be adjusted due to some of the academic calendar reschedules. The implementation of the total quality management was executed on par with the strategic plan.

However several constraints were identified at the analysis stage and these are considered as limitations. One of the limitations is that in case of a change in the floor layout, the device will not work as expected. Therefore it was decided to develop the U1 device only for a particular floor, assuming that there will not be any change in the floor plan. In a case of a floor plan change, the system should be updated with the new floor plan in order to work well.

Another limitation is that in case of a battery failure, the device will not be able to serve as it was intended which means the device will not be available all the time. Therefore, in order to ensure the availability of the device, it is developed with a backup battery to continue the work, in case of a battery power failure.

In order to work 100% accurately and efficiently, the U1 should not face any kind of permanent obstacle on its way while it moves. If the doors inside the floor are closed, U1 has to wait until the doors are open or to inform the server if the timer expires, which takes some more time. Since U1 is developed in order to save time, the floor shouldn't have any kind of situation as mentioned above.

As the U1 device is in an average level of its size, there's a maximum weight it can carry. If it is overloaded, U1 will not be able to move properly as it intended. Therefore to avoid those kinds of problems, the U1 should always load with light weight documents.

Another constraint is that, although the U1 device is developed to provide 100% security for all the documents that it carries, U1 will not be able to work properly if people interfere with objects on the device if they are not intended for them.

For all the operations, U1 needs the connection with its server. In case of failure of this connection, U1 will not be able to proceed. Therefore the wireless connection between U1 and the main controlling server should not be disconnected at any instance.

The future work includes the development of fire detection in the surrounding by the device. It was also planned to come up with a new methodology to implement the image processing of the floor plan in a more efficient manner.

System is expected to use in many real world applications like in automation and electronic engineering. Since there has been no system for office automation in Sri Lanka the team determines that the proposed system will create huge impact on the field of study. Furthermore the team expects that this study will be helpful for the researchers who are interested in artificial intelligence and image processing to design and develop similar models or to develop the same device further and use this concept with other hi-tech automation projects.

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