Autonomous Toddler Surveillance Robot

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Abstract

Parents are the most qualified persons to look after their toddlers. However, there has been instances where the parents were briefly distracted in doing another task and unfortunately, it resulted into the toddlers falling in swimming pools and dying from drowning. This study aims at the design and manufacture of a toddler surveillance robot to reduce the death by drowning in the country. The robot reads the RSSI strength of a Bluetooth signal to identify when a toddler is alone outside and makes use of Computer Vision to locate and track the toddler from a safe distance. Using Deep Neural Network, the robot was trained to recognize if the toddler is playing near a swimming pool or has fallen in it. Thus, it will automatically activate its alarm buzzers to notify the parents about the dangerous situation. The robot uses the Rocker Bogie mechanism to easily move over rough terrain and steps found in a backyard. Moreover, the robot is equipped with a GPS chip to locate its position and before tracking the toddler, it will save its initial GPS location. This initial GPS location is used when the parent comes close to the robot or when the acknowledgement button is pressed, which instructs the robot to return to its initial position.

Keywords— Autonomous robot, Computer Vison, Deep Neural Network, Rocker Bogie, OpenCV

Introduction

Mauritius is a small island in the Indian Ocean. Since its independence in 1968, Mauritius transformed from a low-income, agriculturally based economy to a diversified, upper middle-income economy with growing industrial, financial, and tourist sectors. The island has a surface area of about 2,040 square kilometers and a population averaging at 1.26 million. The island is mainly dependent on the tourism industry, textiles and apparel and the financial services sector but is investing in fish processing, IT technology and hospitality and property development. The total revenue generated by the tourism industry amounts to Rs 5.5 billion (Tradingeconomics.com, 2018) for the year 2017. The Gross Domestic Product Growth rate at market price has been gradually increasing for the past three years. In 2015, it was at 3.5% and in 2016, 3.7%. For the year 2018 the GDP is forecasted to be at 3.8 percent (Ministry of Finance & Economic, 2017).
An increase in Gross Domestic Product of a country means that the economy is improving and that there is an increase in production, thus and increase in expenditure which is a result of an increase in income (Investopedia, 2017). The GDP Per Capita at market prices has also been on the rise for the past five years. In 2015(Statistics Mauritius, 2017) the GDP Per Capita was 324.6 and in 2016 it was 343.6 and forecasted to be 363.6 in 2017. An increase in GDP Per Capita is translated into an increase in revenue and in the standard of living of the population of Mauritius. As a result, many Mauritians can afford luxuries. As the working citizens see their income rising, they tend to improve their standard of living and hence, they tend to afford bungalows with pools or even building a pool for entertainment.

In Mauritius, the nuclear type family is starting to dominate all other types of families. Young couples prefer to detach from the family roots and start a new life on their own rather than staying with their parents. They also have to raise their children on their own and some may even employ a baby sitter to take care of the children. Usually in the nuclear family, both the husband and wife work and have little time for their children. The increase in Gross Domestic Product has for effect that for the employees, the amount of work has increased and there is more pressure on an individual to excel in the job given to him because the employer wants to perform better than his competitors. Parents must also do house chores when they return home. Being from a nuclear family with newborn babies and children, parents feel that they do not have enough time to spend with their children due to the long working hours and lengthy commutes.

Thus, parents often give their children toys to play and hope that the latter will stay in a specific room while they do the household chores. Curious as they are, toddlers will not listen and will often venture around. Unfortunately for people who have unattended pools in their yards, their children want to play near the pool and fall in the water without the knowledge of the parents. Some children have lost their lives as they do not know how to swim and they would breath in water and suffocate by the time that the parents noticed that their children were not in the designated room. Child death by drowning can also happen when the attention of the parents deviates towards other tasks.
There have been numerous cases in Mauritius where children were playing near pools under the supervision of their parents but something happened that made the parent go inside the house for a relatively short period. When they returned, the child had already fallen in the water. Mauritian are also not used to having a baby sitter and there have been many cases of baby sitters ill-treating children and toddlers that they were supposed to take care of. Houses equipped with CCTV cameras also do not help in preventing this situation as cameras will only record video but will not inform parents if their children had an accident.

There has been 1 case of child death by accidental drowning in 2015(Jeeanody, 2016) and 3 cases in 2016 (Jeeanody, 2017) as displayed in the annual health statistics and several more cases this year. The death of your child will affect you for your entire life. A system to detect the probability of a child drowning at an early stage is more than necessary. Therefore, there is an important need to provide appropriate surveillance that will track the movements of a child and inform parents whenever the latter is in danger or falls in a pool.

This paper describes the design and manufacture of a robot that will provide autonomous surveillance of toddlers and alert parents for the application of private swimming pools found in bungalows in Mauritius.

According to the Global Report on Drowning of 2016(Chan, 2017), 372,000 people lose their lives yearly due to drowning. Drowning is the leading cause of death for children of age 1 month to 14 years in the Western Pacific Region, South-East Asia Region, European Region, African Region and many parts of the world. In the United States (Snyder, 2015) an average of 3,536 people dies yearly due to drowning. 76 % of those yearly deaths are attributed to children of 1 month to 5 years old and 67% of the 76% involved swimming pool drowning deaths for children under 3 years old. In 2014 four children died from drowning in a swimming pool in Pennsylvania.

Furthermore, more than 75% of drowning happened in a private residence's swimming pool and 17% happened in an above-ground pool. For 48 out of 85 countries (Wlsl.org, 2018), drowning is among the top five causes of death among children of age 1 to 14. For example, in Australia, the number cause of death among children of age 1 to 13 is drowning. The same applies to China while in Bangladesh, drowning is responsible for 43% of the number of death among children of age 1 to 4. Those numbers are significant and require an effective solution.

Literature review

This chapter describes the specific problem pertaining to security and surveillance of toddlers and how different methods are being used to cater for this need. The research considers cases around the globe and as methodology, both qualitative and quantitative research was carried out.

Global Situation

According to the Global Report on Drowning of 2016(Chan, 2017), 372,000 people lose their lives yearly due to drowning. Drowning is the leading cause of death for children of age 1 month to 14 years in the Western Pacific Region, South-East Asia Region, European Region, African Region and many parts of the world. In the United States (Snyder, 2015) an average of 3,536 people die yearly due to drowning. 76 % of those yearly deaths are attributed to children of 1 month to 5 years old and 67% of the 76% involved swimming pool drowning deaths for children under 3 years old. In 2014 four children died from drowning in a swimming pool in Pennsylvania. Furthermore, more than 75% of drowning happened in a private residence's swimming pool and 17% happened in an above-ground pool. For 48 out of 85 countries (Wlsl.org, 2018), drowning is among the top five causes of death among children of age 1 to 14. For example, in Australia, the number cause of death among children of age 1 to 13 is drowning. The same applies to China while in Bangladesh, drowning is responsible for 43% of the number of death among children of age 1 to 4. Those numbers are significant and require an effective solution. Figure 1 shows which countries have the highest drowning rate in the world.

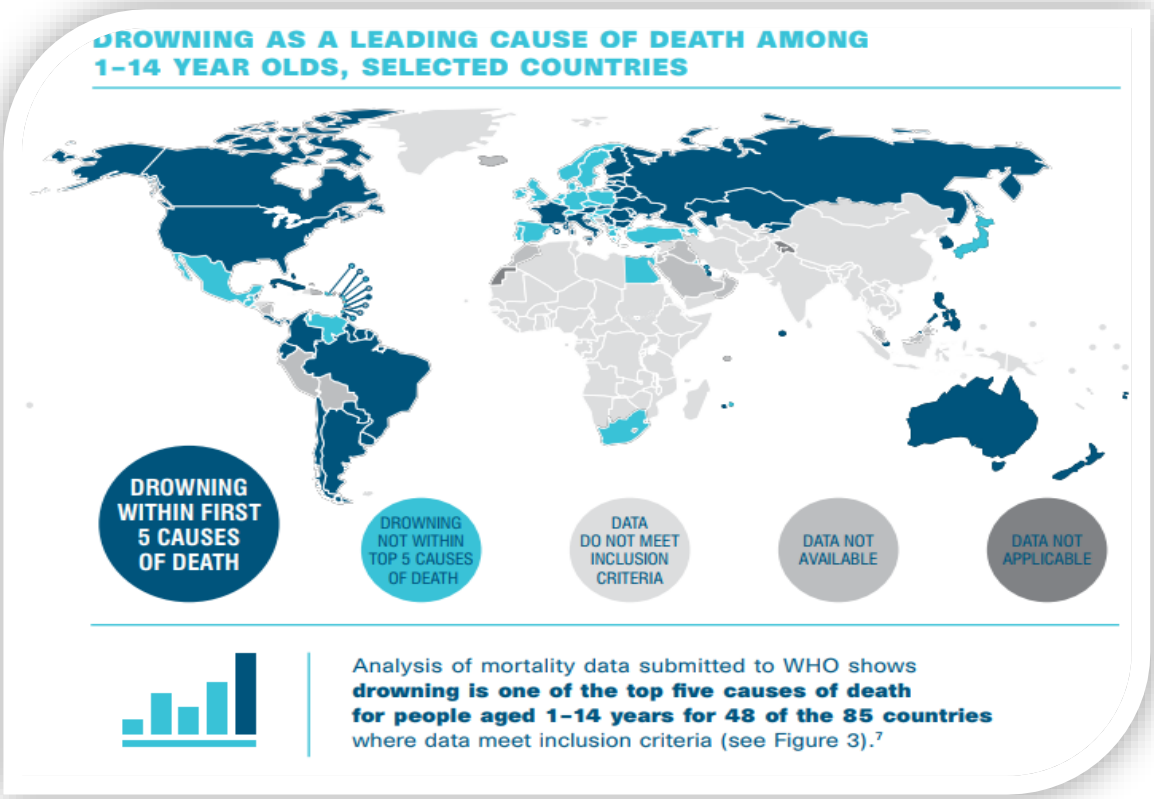

Figure 1 Drowning as a leading cause of death among

The shape of a service robot should be designed for functionality (Rabbitt, Kazdin and Scassellati, 2015), that is, it's shape should be task related, for example, providing telepresence services to allow communication with patients, elderly people or with medical personnel to perform basic operations like object handling or appointment reminding using audio. Such a robot should have camera mounted at a height similar to that of the human eye and a screen on its chest in order for individuals to easily view the latter while being seated or standing. To reduce the cost of manufacturing of such robots, cloud technology should be considered as it allows the effective safeguard of information provided by sensors around a premise which can be used by the robot at any time.

Looking back at 10 years ago, it can be noticed that research concerning the therapeutic use of Socially Assistive Robots (Rabbitt, Kazdin and Scassellati, 2015) to treat dementia has been on the rise. Most of these researches have been carried out to improve Paro, a robot shaped like a baby harp seal, to encourage dementia patients to improve their social behaviours and reduce their stress as shown in figure 2. Socially Assistive Robots have been widely used as companions to train therapy animals, therapeutic play partner to help children with clinically relevant skills and as coach to encourage and supervise people to improve their physical health.

Figure 2 : Paro Robot helping patients

Socially Assistive Robots are modelled in a broad range of design solutions (Pino et al., 2015). There is the machine-like robot which has the shape of industrial robots, the human-like robots, whose shape is similar to the human body and face, the animal-like robot which showcase animal behavior and morphology, the mechanical animal-like robot whose shape is similar to an animal but also comprises of machine features as shown in figure 3. Those designs were defined by Disalvo et al (2002), MacDoman and Ishiguno (2006) and Walters et al. (2009). Locomotion is also a common feature in robots. If a robot is equipped with a locomotion system, it is able to follow or locate an individual or object through remote controlled or autonomously.

The dramatical growth of the older population has drove researches into designing creative solutions to cater for the elderly people using robots. Assistive Human-Robot Interaction deals with robots designed to help people physically, socially or through cognitive assistance. Also, Socially Assistive Robots are being used to help autistic children and elder people to address their social needs via communication. Such as robot is named Paro having the form of a seal and equipped with touch sensors to react in a positive manner that helps dementia patients by improving their mood and generating a calming effect.

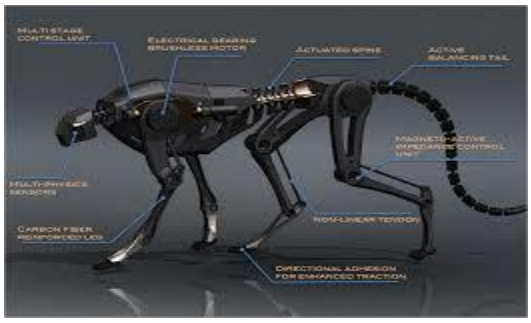

Figure 3: Mechanical animal-like robot

Moreover, more advanced technology is being developed in the field of eldercare which will help people to stay at home and live independently most of the time (Rabbitt, Kazdin and Scassellati, 2015). For this application, the premise of the individual must be equipped with a range of sensors that provide services like indoor user localization, activity and event recognition, user health status assessment and so on. A suitable robot needs to be interfaced with smart systems and cloud assisted devices in order for it to effectively help individuals within their premise or in a nursing home while contributing to the enhancement of their standard of living. A robot with a wheel-based platform with an interactive screen for user interface is also very effective. Examples are: Kompai robot in the Domeo Project, Care-O-bot in the Accompany Project and Saitos G3 in the Companionable Project. Another example is the Giraff robot in the Excite Project which uses a camera for telepresence as shown in figure 4.

Figure 4: Giraff Robot

Cameras are the most accurate way to identify the situation in which an individual is. Following incidents, crimes and other activities, security officials have access to numerous surveillance cameras to determine why such activities took place. However, Robert Collins, Alan Lipton and Takeo Kanade (Collins, Lipton and Kanade, 2000) argue that the method

used to operate surveillance cameras are not effective. They think that the video data are examined only after an incident took place. If those data are used for forensic purposes, they will not have the benefit of being an active, real-time medium. They suggest that a continuous 24-hour surveillance system that would alert authorities while a crime is being committed or even before it is committed, is required and it should possess features such as detection and tracking, human motion analysis and activity analysis. Detection and tracking extracts a moving body from video data in real-time and continuously tracks the body to create possible trajectories that the body can take. The human motion analysis deals with the periodic detection of an individual's gait and obtaining data about the pose of the human body. Finally, activity analysis uses momentary series of human observations to create highly accurate descriptions of the agent's actions either as a single person or as a group. This method will be useful in the case of toddlers being in difficulty near pools or other dangerous regions as the intelligent system will be able to determine if the toddler needs help and it will alert the parents or authorities.

Detecting an individual in a complex environment in an image is challenging. Different parameters have to be defined within the software in order to accurately detect the face of the person and the actions of the individuals being shown in the image. It is more challenging to perform this operation in real time image or video streaming as the software must be able to deal with numerous lighting conditions, a changing background, changes in posture and variation in the dimensions of an individual dues to varying distance. A research was carried out by a team at Innovative Imaging and Research (Loce et al., 2013) to be able to detect pedestrians on the road for safety issues. One of the approaches used by them is motion detection. It easier to detect an individual via a method known as optical flow which indicates a region of interest. This region can then be deeply analysed for shape, size and gait. Clustered areas of pixels within the region of interest is generated by the locomotion of the human body and this can be used as feature to track corresponding clusters from one frame to the other. For motion detection, multiple frames are acquired and examined in parallel with changing background, lighting conditions and longitudinal locomotion. In addition, to address the problem of range and size ambiguity, two cameras are used instead of one. Combining detected features such bounding box dimensions and size with disparity maps obtained from the two cameras, the distance between the individual and the camera can be obtained.

As of now many computer vision algorithms have been developed regarding the security and safety of individuals. For example, a team at the University of Essex, leaded by Professor Klaus McDonald-Maier (Lamb, 2017) has created a software that uses computer vision to recognize plausible abuses of human rights. By analyzing the large quantity of images from security cameras, social media platforms and other sources, it will identify any type of abuse and group similar abuses together. This would help individuals to easily and quickly go through the images for further investigation. The software basically uses the concept of neural network to effectively process large amounts of data sets. The concept of neural network is similar to that of the neural network of the human brain, normally the visual cortex. Prior testing was carried out using 5,000 images as input. 100 of these images depicted violation of human rights, such as child labour and child violence and the system could detect those violations at 88.1% accuracy. However, the system uses non-real-time images and by the time that an image is grouped and analysed by the team at the University of Essex, a child's life might be at risk and even worst conditions such as death. Such an accurate system might also require high computational power to process the images at an elevated rate. These theories will be of great help in implementing a proper vision system to cater for the identified problem. Figure 5 shows the process and result of a particular type of computer vision.

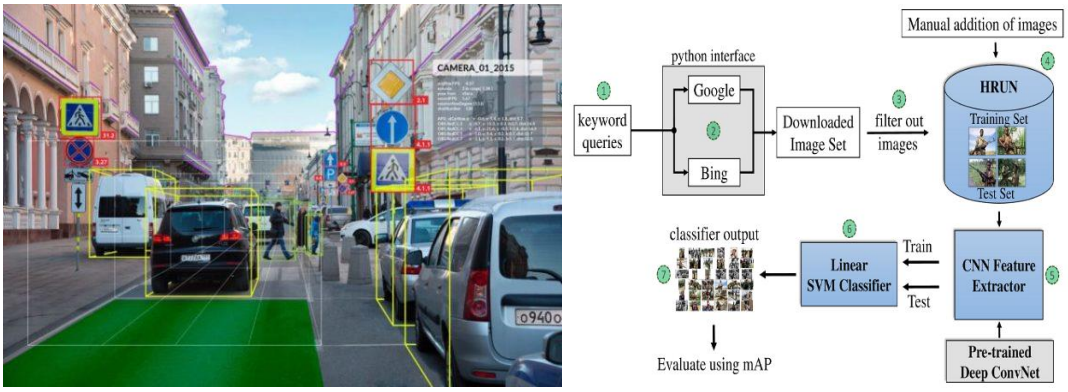

Figure 5 : Computer Vision Algorithm

Professor Howard Dubowitz (Dubowitz, 2013) carried out a survey in a community in 2006 to find out the rate of children neglected by parents. The results were that an astonishing 30.6 per 1,000 children were neglected by their parents. The parents were either too busy by the technological advancements of the modern world such as mobile phones and tablets or they were busy with their work. Start-rite (Cliff, 2017) published a video revealing how children felt about their parents being constantly on their phones and not paying attention to them. The children's age ranged from 7 to 11 years old. The feeling of being left alone affects the psychological health of the children. Neglecting a child could result in catastrophic long-term effects such as health issues, cultural issues, drug exposure and in this case, inappropriate protection from environmental hazards. This information suggests that young parents are not as caring as old parents and this case is equal for children under 7 years old also. Inadequate supervision from parents would result in risk-taking behavior from toddlers and children and they could venture outside the house without anyone knowing. From the above information, it can be concluded that a new method to save children from the effects of being neglected, needs to be implemented.

I. THE SYSTEM

The main objectives of the project are to design a machine that will be able to monitor a toddler, to warn parents if child is not in a designated area, to reduce the stress on parents to constant surveillance, to provide a safe playing environment for the toddler, to track and locate the child the moment he/she leaves the designated area or enters a dangerous zone, to follow the child wherever he/she is going and to design and develop an affordable solution to reduce the drowning rate of toddlers.

The product specifications have been determined and the autonomous toddler surveillance robot will consist of the following subsystems:

- Autonomous robot
- Toddler Tracking system
- Danger Estimation system
- Return Home system
- Charging system

Figure 6 shows the main processes of that the robot will have to carry out in order to precisely track a toddler.

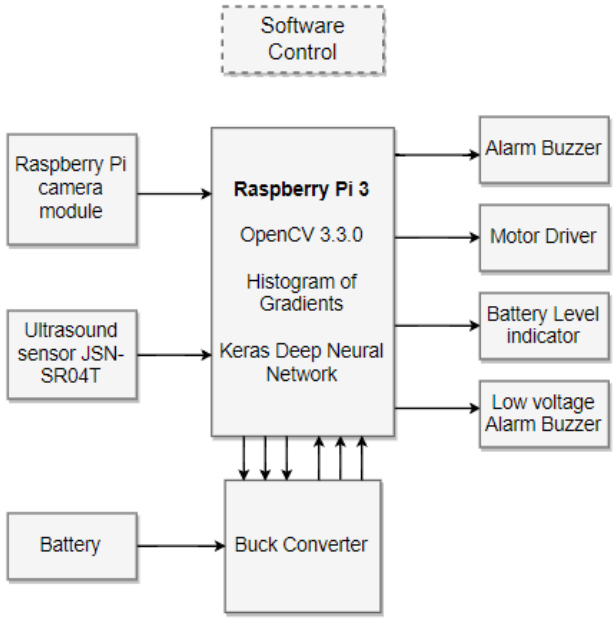

Figure 6: Main Processes Block Diagram

II. SUBSYSTEM DESIGN

The different subsystems have been designed and tested separately before integrating them together. The main components and functions of the different subsystem are discussed in the subsections below.

A. Robot

The robot is designed to easily move in backyards of bungalows using the Rocker Bogie mechanism and is resistant to bad weather conditions since it will have to be placed outside of the bungalows. The latter has non-attractive colors in order not to catch the attention of the toddlers during service.

Ideally, the robot should be placed in such a position that it faces the door that gives access to the backyard and swimming pool. However, the robot will look for the toddler by rotating on itself using differential drive rather than steering.

As the robot will be placed outdoors, during summer the temperature inside the body of the robot can rise drastically causing the electronic components and the Raspberry Pi to overheat and not function properly. To cater for this problem, a DHT11 temperature and humidity sensor will be used to monitor the temperature and humidity within the body and turn on a 12V fan if the temperature rises above 45°C and if the humidity rises above 50%.

Since the body needs to be waterproof, able to withstand a 98.1N(10kg) average weight and hollow, High Density Polyethylene(HDPE) of thickness, 5 mm is suitable for this application. This material has a hardness rating of 67 from the Shore Hardness ASTM D2240 test and is resistant to weather and sunlight. It is also lightweight, non-toxic, corrosion and chemical resistant, has high tensile and impact resistant and does not absorb moisture. From an environmental point of view, High Density Polyethylene is 100 percent recyclable, thus, it will help to protect the environment.

Figure 7 shows the different parts required to form the robot.

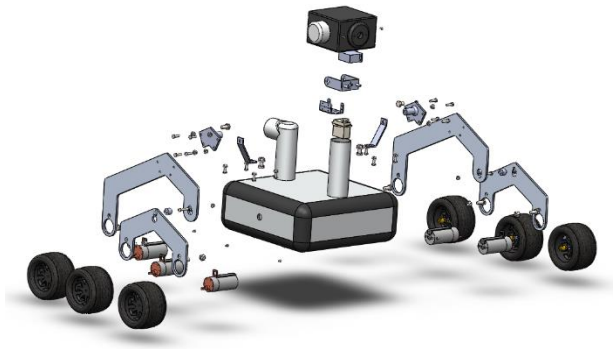

Figure 7: Exploded view of robot

The rocker and the bogie will made from EN-AW 6061 T4 aluminium alloy as the alloy offers a combination of good workability, medium strength, high fatigue strength, good weldability and high resistance to stress corrosion cracking. It has also a high strength to weight ratio and is available in Mauritius.

The Rocker Bogie mechanism has proven its efficiency on the Mars Rover in its ability to move over obstacles with high stability. This mechanism consists of 6 driven wheels with the two front ones providing steering as well. The wheels are mounted on a frame consisting of two movable joints to keep the body of the robot as horizontal. A counter rotating differential bar is used to stabilize the body of the robot on uneven surfaces. The advantage of this mechanism is that the total weight of the robot is distributed evenly on the 6 six wheels, thus reducing the torque required for each

motor. Simulations have shown that this mechanism is stable on rough surfaces and all the wheels are always in contact with the ground. (Popinski, 2017) However, for this application, the body will remain fixed to the rocker and the up and down motion will be compensated using the MG995 servo attached to the camera.

The robot will have locomotion using six 99:1 Metal Gearmotor HP 12V 100 RPM DC motors, three on the left side and three on the right side. Two H-bridge BTS7960B motor drivers will be used to control the speed and direction of rotation of the motors, one motor driver controlling the left side motors and the other one controlling the right-side motors. The BTS7960B can be used for application requiring up to 43A which is enough to run three DC motors at once since one DC motor has a continuous current of 2 Amperes and can peak at 9 Amperes.

The robot will be powered by a 20,000 mah Lithium Ion polymer battery which will provide 1 hour of continuous motion to the latter. The battery will be connected to the battery level indicator so that the user knows when to charge the robot as well as a low voltage alarm buzzer to warn the user that the battery needs charging. The battery has an integrated overcharge and undercharge circuit to protect it. The robot has a main 12V 30A toggle switch connected directly to the battery which when turned off, will completely shut down the system. This was integrated as a safety measure. The battery will also supply the Raspberry Pi via a 12V to 5V 2.5A buck convertor and the servo motor using a 12V to 5V 1A buck convertor.

Figure 8: The Autonomous Toddler Surveillance Robot

The raspberry pi is cheaper than the Beagle Bone and is powerful enough to implement a computer vision software such as OpenCV whereas the Arduino Uno does not have enough memory to perform the required processes. However, it is easier to control motors and servos using the Arduino. The Beagle Bone and Arduino do not have integrated Bluetooth and WIFI for easy installation of computer vision programs.

The robot is controlled using the Raspberry Pi 3 Model B and the RaspiCam for acquiring vision. The Raspberry Pi is powerful enough for medium precision and medium speed tracking using Deep Neural Networks and Histogram of Gradients in OpenCV. Moreover, it has sufficient GPIO pins to control different components of the robot as well as providing Bluetooth capabilities. The 5MP of the RaspiCam is decent for tracking purposes and it is fully compatible with the Raspberry Pi. The camera is connected to the Raspberry Pi using a 15Pin flexible ribbon flat cable wire of length 70 cm.

B. Toddler Tracking System

The robot will be in standby mode while the Raspberry Pi detects that the Bluetooth strength of the parent's and toddler's Bluetooth tags are within 20 dBm to each other. The Bluetooth tags use Bluetooth 4.0 for low power

consumption. As soon as the difference between the two RSSI strength is greater than 20 dBm, the Raspberry Pi will start analyzing the frames acquired from the RaspiCam. If no human is detected in the images, the robot will start to rotate on itself through differential drive until it detects a toddler.

The Raspberry Pi acquires 30 frames per second from the camera and uses Histogram of Gradients Detection from the OpenCV software to recognize the silhouette of a person. OpenCV is an open source program that is able to extract data from an image or a video such as details about a person's face for face recognition. Once detected the person is enclosed in a rectangular box to define the actions of the robot based on the area and position of the box in the image. The area of the box is used to move the robot either forward or backward whereas the position of the box is used to control the left and right motion of the robot and the up and down motion of the camera which is connected to an MG995 servo motor. Thus, the use of Histogram of gradients allows for the tracking of the toddler once it has been detected.

C. Danger Estimation System

For this project Deep Neural Network and the Keras have also been used to estimate the level of danger in each frame captured from the camera. Keras is a high-level neural networks application programming interface (API), written in Python and capable of running on top of TensorFlow. The procedure consists of using a dataset of images containing toddlers near and in swimming pools (positive images) and images of random objects and scenes (negative images). Both set of images will be used to train the robot in estimating the percentage of danger in real time and take appropriate actions immediately. Once the Keras model has detected a dangerous situation, it will output a high signal to the alarm buzzer relay which will activate the two alarm buzzers on the head of the robot to alert the parents. The buzzers can only be turned off when the acknowledgement button is pressed which will also activate the return home function.

D. Return Home System

The Raspberry Pi also record the initial GPS location of the robot when the Bluetooth RSSI signal difference is greater than 20 dBm. This is done via the Ublox NEO M8N chip. The initial GPS location comes into use if the RSSI Bluetooth signal difference between the parents' and toddler's Bluetooth tags become less than 20 dBm again or when the acknowledgement button is pressed. The robot then returns to its initial position, hence, the return home function. A HMC5883L compass module is used to enhance the precision of the robot to find its way back.

The robot was designed to move over rough terrain, small rocks and steps normally found in a backyard. It can also avoid obstacles detected using the JSN-SR04T waterproof ultrasound sensor and move around the obstacles. This function only works when the robot is in "return home" mode and when an obstacle is within 35 cm in front of the robot as during tracking a toddler would normally avoid an obstacle and move around it and the robot will follow the path of the toddler.

E. Charging System

The robot can easily be charged using a 230V to 12V 10A wall adapter for fast and safe charging. The battery is connected to a 3.5 mm charging port as well as a voltage cut off circuit in order to prevent overcharging.

III. PROTOTYPE

The prototype was tested against the functions it has to carry out, to see how well it satisfies the aim and objectives of this project

A. Stability Test

On flat ground and slightly inclined surfaces, the robot is stable. However, since the lithium ion battery had to be replaced by a heavier lead acid battery, the robot tends to fall backyards when climbing stairs of height 15 cm. This issue was resolved by moving the battery to the front of the body of the robot. The center of gravity moved forward and thus the robot was able to climb stairs.

B. Bluetooth Tracker Activation Test

The Bluetooth signal from the toddler's Bluetooth tracker successfully activated the robot when it detected that the toddler's Bluetooth signal was stronger than the parent's Bluetooth signal, thus, indicating that the baby or toddler was roaming alone.

Figure 9: Bluetooth tag

C. Toddler detection Test

The system successfully detected the toddler by drawing a rectangle around him as shown in figure 54. Several images of toddler walking were used to test the system and it had a 95% accuracy. The accuracy could be made 100% but the raspberry pi would become very slow as it would be working at 100% which leaves no memory for other functions.

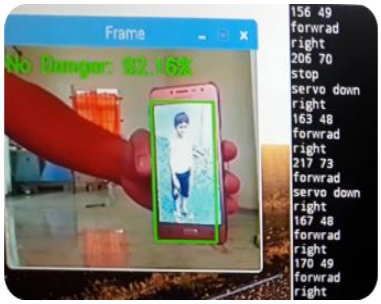

Figure 10: Toddler detection and Tracking

D. Toddler tracking test

The robot could track the toddler with a success rate of 90% in the real world. This was due to that the raspberry pi was working at 95% of its full capacity and the video streaming was delay by a few milliseconds. This normally happened when the toddler was running but while walking a good performance was achieved. The robot was also able to follow the toddler from a safe distance.

E. Danger estimation Test

During software testing, the results showed that the system could detect dangerous situations such as a toddler walking near a pool or bending over the pool to pick up a toy as shown in figure 55. There were some false alerts from the system due to the fact that only about 217 images of toddlers and babies in a drowning position was available. During the training of a neural network, having equal number of positive and negative images is favorable. Thus, the system was trained on 434 images only as there is no online dataset for drowning situations. This issue can be resolved if a dataset with much more images could be used to train the network.

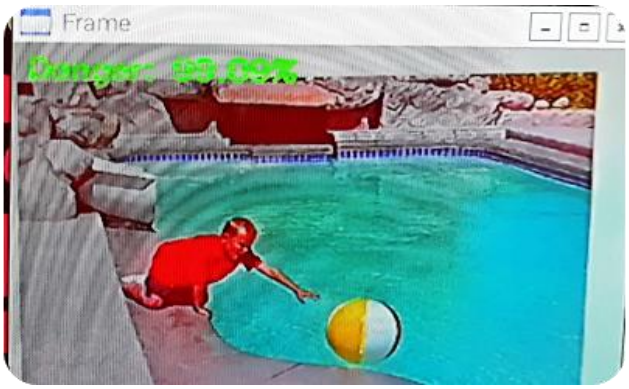

Figure 11: Danger Estimation by Keras Model

F. GPS Return home function Test

The probability of success for the return home function was 50 %. In Mauritius, the GPS service is not as accurate as other countries and moreover there are trees and other obstacles that prevent the good reception of the GPS signal. The neo M8n GPS module has an accuracy of 0.9 meters. However, in backyards having large trees, it was difficult for the robot to find its way back to its initial position. The robot is still light enough for a normal size adult to pick it up and drop it at its initial position.

G. Cooling fan Test

The cooling fans successfully start when the temperature of the body of the robot reaches 55 ^{0}C and help to dissipate the internal heat. The fans successfully turn off once the temperature goes below 55 ^{0}C.

IV. CONCLUSION

The robot satisfied its aim and objectives. It was able to read the Bluetooth signal strength of a toddler's Bluetooth tag and determine whether the toddler was roaming alone, by calculating the difference between the RSSI strength signal of the Bluetooth tags and started looking for him/her when the difference was more than 20 dBm which is equivalent to a wall blocking the Bluetooth signal of the parent's Bluetooth tag. The robot was also able to detect a toddler and follow him/her within a safe distance (about 2 meters) while being more accurate at the walking speed of the toddler compared to the running speed of the toddler.

The robot is able to accurately estimate the amount of danger in a given situation 8 out of 10 times. The accuracy can be improved through further training and testing. Furthermore, the robot is able to maintain a safe working temperature within its body which is 55 ^{0}C. This contributes to the good performance of the microcontroller, sensors and battery lifespan safety.

Overall the project was successful and will be able to help reduce the number of death by drowning of toddlers as well as providing a safe environment for them. Parents will also be warned by a sound alert of about 120 dB if the toddler is in danger. OpenCV and computer vision in general is still under development, thus the system is not perfect and can be enhanced through further testing and training. Dataset are also not easily available which can contribute to the enhancement of neural network of the robot.

Lastly, it has been found that using neural network, the robot can be modified very easily for other vulnerable age groups such as monitoring the safety of elder persons and handicapped persons. This can be done by changing the dataset used to train the robot and defining other dangers that the latter needs to detect. The price of the prototype is high as it is a one-off production. If mass produced, the price will be reduced. Rs 18,182.75 (USD 542.76) is relatively cheap compare to other companion robots discussed in the existing model section and they do not offer danger detection services.

For example, Aristotle (Martinko, 2017), which is a fixed camera mounted on a table for real time video streaming and lighting control only, costs USD 400 (Rs 13,400), PaPeRo (Partner type Personal Robot) companion robot costs USD 600 (Rs 20,100) **per month**, Kuri robot (Heykuri.com, 2017), costs USD 799 (Rs 26,766.5) Ipal Robot (ipalrobot, 2017) cost between USD 1,500 and USD 2,000 (Rs 50,250 to 67,000) and Jibo robot costs USD 900 (Rs 30,150).

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Biographies

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D. Errappa is a final year student of the University of Mauritius studying Bachelor of Engineering in Mechatronics Engineering. He started this project with the help of his supervisor, Dr Santaram Venkannah as a fulfillment of the requirements to complete his studies.