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An Automatic Drowning Detection and Rescue System

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Abstract: Drowning is the third most leading cause of unintentional injury death worldwide, accounting for the third cause of unplanned death globally, with about 1.2 million cases yearly. In 2016, an estimated 320,000 people died from drowning, making drowning a major public health problem worldwide. It is very complicated to rescue a drowning victim as it takes time to sense the victim in water by standard ways like fire force or drivers. Hence, the proposed system involves an automatic drowning detection, and embedded system technique which involves continuous monitoring of the victim's medical condition. The sensing devices include heartbeat sensor, pulse oximeter and pressure sensor to detect pulse rate, oxygen level and inspiration pressure respectively. Any medical abnormality detected in the victim's body will trigger a rescue system which involves balloon inflation process. The device will be worn by the victim in the wrist, which, upon inflation, will pull the victim to the surface of water, thereby saving the person. An alarm system will also be triggered to indicate the nearby people to rescue.
Keywords: Embedded System, Heartbeat, Pulse rate, Oxygen level, Inflation, Inspiration pressure

I. INTRODUCTION

Drowning has been a significant issue for death worldwide. Approximately 500,000 deaths due to drowning are reported annually out of which 30,000 deaths happen in India. It is very difficult to detect a drowning person and takes time to measure the body abnormalities as it changes with respect to the person's age, gender, height and weight. Our proposed design detects various medical parameters using sensors and will detect the drowning person by continuous analysis. The heartbeat sensor, pulse oximeter and pressure sensor will measure pulse rate, SpO2 and inspiration pressure respectively. Any abnormalities in any one of the parameters will trigger the rescue system which will inflate a balloon from a wrist band. A buzzer will also be triggered in order to alert the public for further rescue. Upon balloon inflation, the person will be pulled to the top of the surface of water, thereby, saving the person from drowning.

A. Need of the Hour

Although there are various provisions put in place from drowning in some countries, it still accounts for the primary cause of unplanned death. Eradication rather than cure has helped in minimizing the number of individuals who drown generally, except in developing nations, who lack adequate educational facilities and enforcement of safety measures on the danger of drowning, thereby making the burden of drowning to escalate. Hence, the need of the hour is to implement a strategy to make people be aware of the risks involved in getting into water.

B. Objectives

The study of various drowning cases has helped in figuring out the following goals of our proposed system:

1) Detect the drowning victim by monitoring the body abnormalities.
2) Help the victim land up to the surface of water automatically.
3) Alert the nearby people to help the victim land the shore.

II. LITERATURE REVIEW

There is a wide range of uncertainty around the estimate of global drowning deaths. The data categorization methods for drowning exclude intentional drowning deaths (suicide or homicide) and drowning deaths caused by flood disasters and water transport incidents. Various studies were made which included analysis of drowning cases at some parts of our country and water bodies, research paper analysis, existing devices functionality and its advantages and limitations, analysis of victim's age, gender, height and other parameters.

A. Case Studies

The drowning process has been well studied and the results are known to most physicians. The purpose of this study is to obtain information about the clinical symptomatology, pathophysiology, and pathological anatomy of human near-drowning based on medical records and pathological examination of cases. Post-mortem examination of 159 human drowning victims were made out of which 77 were selected for study on the basis that the victims were apneic and comatose when rescued. Upon analysis, many 59 victims were diagnosed with the effects of hypoxia, hemorrhagic pulmonary cedema, aspiration pneumonitis and, in a few instances, to minor barotrauma.[2]

A 23-year-old Caucasian male fell unconscious while diving and his head was submerged in water, for approximately four minutes before he was carried to the bank, laid in a prone position, and given artificial respiration. Much water was noted to run from his mouth. He shortly regained consciousness and soon stood up, although he was hysterical and breathing with difficulty. He was taken immediately to the near-by military hospital. Physical examination revealed a well-developed young male who was disorientated and in a semi-comatose condition, cyanotic and in respiratory distress. Temperature 96 deg F, pulse 100, respiration 32, blood pressure 110/44. There was mild splinting of the right chest, and breath sounds were diminished on the right. There were bilateral rales, but no dullness. Aside from tachycardia, auscultation of the heart was negative. Five and a half hours after the accident, the patient was conscious and well orientated though he complained of pain in his right chest. Diffuse pulmonary rales, crackles, and wheezes increased. Twelve hours after the accident tachycardia had increased, blood pressure was 100/40, respirations were rapid and shallow. Hemoglobin 13 g/100 ml, hematocrit 37%. He was placed in an oxygen tent, but respiratory distress increased and he died eighteen hours after the accident.[3]

A 30-year-old male was submerged for an estimated five to eight minutes when the motor vehicle in which he was riding overturned into fresh water. Mouth-to mouth rescue breathing was administered by a highway patrolman with return of spontaneous respiration; and the child was transported to a hospital. He was deeply comatose, did not respond to painful stimuli, and was areflexic. Blood pressure 100/60, pulse 100, respiration 68. There were bilateral moist rales. Heart sounds were regular and rapid. A large amount of muddy water was removed by tracheal suction. Tracheotomy was done and intravenous dextrose, water, and aminophylline were given. X-ray examination of the chest revealed bilateral mottled densities in the lung fields. There appeared to be some decrease in the depth of coma, and about three and a half hours after the accident he began convulsing, which was controlled with intravenous amylobarbitone. Following this, for several hours he was restless and moving about, but never fully conscious. Hematocrit 37%, hemoglobin 12-4 g/100 ml. Penicillin and streptomycin were given. About fifteen hours after the accident there was considerable increase in respiratory difficulty and he expired.

A study of the records of 77 near-drowning patients including the autopsy material from 20 delayed drowning deaths indicates that although these patients have aspirated significant amounts of water, profound blood volume changes and electrolyte disturbances are not produced, or are corrected too rapidly to be detected clinically. Signs and symptoms constituting the post-immersion syndrome, by correlation with the autopsy findings, can be ascribed to hypoxia, pulmonary cedema and aspiration injury to the lung. Significant differences in the clinical pathology of near-drowning victims are not usually produced by differences in the salinity of the drowning fluid.

B. Existing Devices

Drowning is classified into two, active drowning and passive drowning. In the active drowning, the victim express distress that is noticeable to others. In passive drowning, there is no distress exhibited by the victim. The passive drowning happens due to medical reasons like stroke; heart attack etc. or it could be that the person has become unconscious. Passive drowning victims generally have their face down underwater and, in some cases, will be floating below the surface. All these characteristics make the detection of drowning difficult for even professional lifeguards.

With the advancement in technology, various drowning detection methods are available. There are few devices which are to be kept stationary at a water body shore like Coral Manta. It is a computer vision based drowning detection system for residential swimming pools.[1] It works based on artificial intelligence to track everyone in the pool and detect risk of drowning continuously. The major limitation of the device is that it requires adult supervision all the time. It also requires internet connection which makes it unfeasible for implementation of the device near water bodies in rural areas.

Some detectors are wearable like Kingii. Fig-1 shows the smallest flotation wearable device for swimmers. It could provide additional buoyancy in water using a wristband that can easily be activated in times of need. It cannot replace a life vest or Personal Flotation Device, but can provide additional buoyancy in times of need.

Fig. 1 Kingii Pro Lightweight Wearable Portable Recreational Water Buoyancy Aid Device

Another existing device is the Goksu wearable life jacket which communicates with the life guard and also gets inflated during danger. Fig-2 shows an inflatable air bag which pops up instantly with a simple triggering of the lever taking the victim to the surface. Yet, both the devices are very expensive and of less quality and are manually operated during critical conditions. There are several other similar devices which lack in performance and durability. Hence, these analyses highlighted the drawbacks and provided various inferences for its improvement.

Fig. 2 Göksu Portable Wearable Safety Inflatable Rescue Life Jacket Device

C. Comparison Charts

In the surveys, for each case of drowning in any community, the outcome was categorized as: 'died immediately'; 'initially survived but later died'; 'survived with permanent disability'; or 'survived with no permanent disability'. Several statistics were analyzed based on the age, gender, location, country and many more factors. Some of the major statistics which contained significant amount of information were analyzed.

Fig-3 and Fig-4 shows the survey that observed increase in number of drowning cases viz. 58 and 78 in year 2013 and 2014 respectively, of district Rothak, Haryana. It showed that Males are especially at risk of drowning, with twice the overall mortality rate of females. They are more likely to be hospitalized than females for non-fatal drowning. Studies suggest that the higher drowning rates among males are due to increased exposure to water and riskier behavior such as swimming alone, drinking alcohol before swimming alone and boating. It is also noted that, there are more drowning cases in the month of June, which shows that people go for swimming during summer seasons, thereby becoming a drowning victim. In addition to that, there are equal number of accidental and intentional drowning cases.

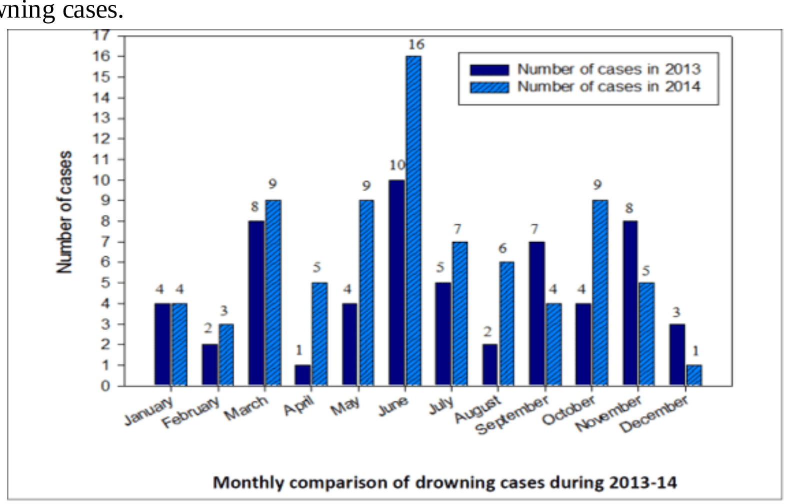

Fig. 3 Survey of Number of Monthly Drowning Cases viz. 58 & 78 in 2013-2014 respectively, Rothak, Haryana.

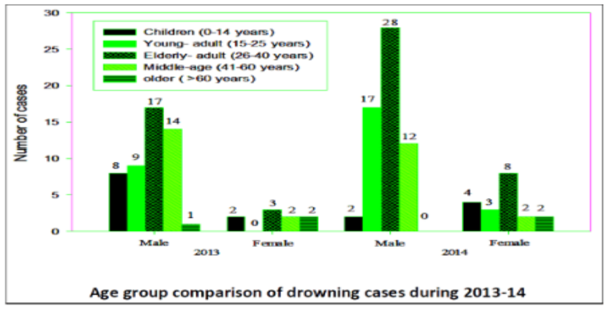

Fig. 4 Survey of Number of Gender-wise Drowning Cases viz. 58 & 78 in 2013-2014 respectively, Rothak, Haryana.

In order to analyze the age of the victim, the survey of distribution of drowning deaths by the activity prior to fatal drowning based on age groups, sex and place of residence for children aged 1 –14 years in the Indian state of Bihar was studied. Fig-5 shows that children of age 10-14 are more prone to drowning. It could be due to unawareness of drowning accident and the negligence of adult surveillance. Also, there are equal number of cases irrespective of the location of water body. From this, we can conclude that, irrespective of the age, gender and place of living, the victim must be rescued.

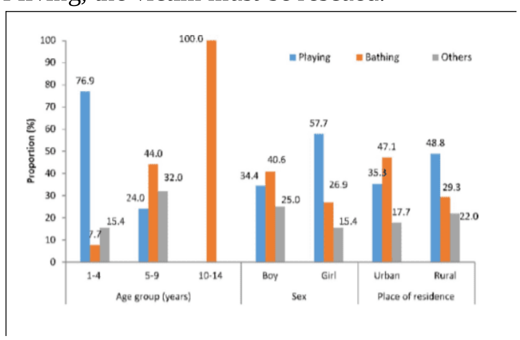

Fig. 5 Survey Based on Age Groups, Sex and Place of Residence for Children Aged 1–14 Years, Bihar

There are other factors that are associated with an increased risk of drowning, such as:

1) Lower socioeconomic status, being a member of an ethnic minority, lack of higher education, and rural populations all tend to be associated, although this association can vary across countries.
2) Infants left unsupervised or alone with another child around water.
3) Alcohol use, near or in the water.
4) Medical conditions, such as epilepsy.
5) Tourists unfamiliar with local water risks and features.

From all the data and statistics mentioned above, we conclude the following inference:

a) People from rural areas are more prone to drowning than people from urban areas. So, the device must be easily affordable & cost-effective.
b) Internet connectivity cannot be expected at all places. So, the device must be accessible anywhere.
c) Male and female of different age divisions are affected. So, the device must be easily wearable at all cost.
d) Anything that is measured under water requires proper figures. So, the functioning of the device requires high accuracy.
e) To make it feasible for everyone, the device should be of lightweight and compact.

III. PROPOSED SYSTEM

The proposed system will help in both detecting and rescuing the victim from drowning. The system gives an alert signal if the detector triggered an abnormal heartbeat, oxygen level or inspiration pressure when the victim is submerged under the water for a long time. The victim's body parameter abnormality will depend on their age, gender, lung capacity, height and weight. This makes a point that the victim must be detected irrespective of who they are. Hence, when the threshold is surpassed, an alert signal from any one of the sensors will be considered for triggering the rescue system.[4]

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A. Features

Considering all the advantages and limitations from the research done and analyzing existing devices, Table-I shows the features in order to implement the working prototype of the system.

TABLE I

Medical, electrical and general features

Medical features	Electrical features	Other features
Oxygen level	Less power consumption	Lightweight & Compact
Beats per minute (BPM)	Battery operated	Highly accurate
SpO2	Display watch	Highly durable

B. Block Plan

All the required hardware electronic components were figured out and a basic outline structure for the circuit design was constructed by properly placing the device at the appropriate positions. Fig-6 shows the block diagram of the entire setup and its structural plan.

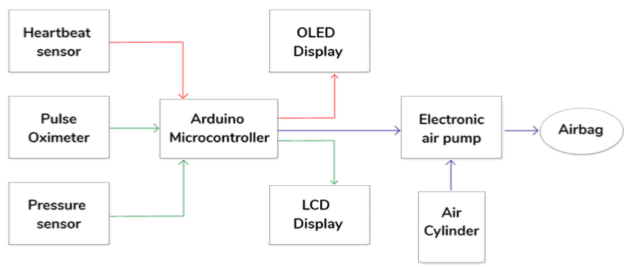

Fig. 6 The Overall Block Diagram of The Proposed System

The block plan shows that the heartbeat pulse sensor is interfaced with an OLED display through microcontroller. The pulse oximeter and pressure sensor are interfaced with an LCD display through the microcontroller. An electronic air pump is connected to an air cylinder and is interfaced with the microcontroller to inflate an airbag attached to it.

C. Design Flow

The system aims to curb deaths from drowning by observing the rise and fall of the heart rate, inspiration pressure and oxygen level of a swimmer or non-swimmer in water and if endangered, sends a signal from the wearable device attached to the wrist of the victim who maybe undergoing a near drowning experience to the rescue system in order to inflate the balloon using an air pump and save the person. Fig-7 demonstrates the design flowchart of step by step working of the system prototype.

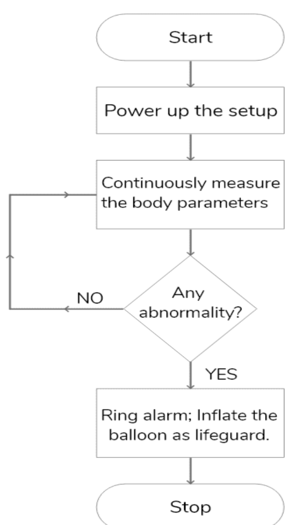

Fig. 7 The Overall Design Flow of The Proposed System

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IV. VICTIM ANALYSIS

The drowning process has been well studied and described in experimental animals; and the results are known to most physicians. Briefly, the events which take place before death of the animals can be ascribed to the effects of asphyxia and to the biochemical effects resulting from the transfer of water and solutes between the drowning fluid aspirated into the lungs and the blood stream. There are several rescue techniques like lifeguard vests, fire engine service and so on. But it would take a lot of time to save the victim from downing. Hence, the system should be automated instead of manual operation. The proposed rescue system involves a balloon inflation technique from a wrist band of the swimmer using an air pump and an air cylinder.

A. Medical Analysis

Upon analysis of a drowned victim, the following observations were made. There is a rapid fall in blood oxygen and a rise of carbon dioxide. Glucose is mobilized; fibrinolysins are released; and there is a tendency to capillary hemorrhage. Hemolysis may occur. There is at first stimulation of the central nervous system with convulsions, hypertension, vomiting, micturition, defecation, and seminal emission. This brief period of stimulation is followed by depression with deep coma, vascular collapse, and the slowing of respiration and heart action to the point of death.

Biochemical effects vary with the electrolyte content of the drowning fluid, and result in marked changes in blood volume and blood electrolyte concentrations. Regardless of the salinity of the drowning fluid, there is loss of plasma into the lung alveoli. In fresh-water drowning intravascular osmotic homolyzes and elevation of plasma potassium occur. Ventricular fibrillation occurs terminally in some species of mammals drowned under experimental conditions. Post-mortem examination of human drowning victims indicates that similar events take place in humans in the majority of instances. Forensic pathologists, in their efforts to develop methods of diagnosing drowning -deaths, have demonstrated that the water and electrolyte exchanges that occur in the experimental animal take place also in the fatal human drowning.

Hypoxia is the term used to indicate a deficiency of oxygen. A related term that is often used in relation to perinatal brain injury is anoxia, meaning without oxygen. Asphyxia refers to the physiological results of hypoxia or anoxia. We measure blood oxygen levels in our bodies to ensure that everything is working as it should be. Using a Finger Pulse Oximeter, which is a small device that is attached to your finger to measure the amount of oxygen in the blood travelling round your body. The Oximeter takes an SpO2 reading – an estimation of the amount of oxygen in your blood. Oxygen is carried around your body in your red blood cells by a molecule called hemoglobin. A finger pulse oximeter measures how much oxygen the hemoglobin in your blood is carrying. This is called the oxygen saturation and is a percentage (scored out of 100). An SpO2 reading of 95% or more is generally considered to be a normal oxygen level. An SpO2 reading of 92% or less could indicate that your blood is poorly saturated. Insufficient saturation can cause issues such as chest pain, shortness of breath and increased heart rate. Oxygen levels below 90% are considered abnormally low and would be classed as a medical emergency. Insufficient saturation can cause a range of adverse health conditions including chest pain, shortness of breath and increased heart rate.

Heart rate, or pulse, is the number of times your heart beats in 1 minute. Heart rates vary from person to person. A normal resting heart rate is usually between 60 and 100 beats per minute. Children tend to have higher resting heart rates than adults. The maximum heart rate is, on average, the highest the pulse can get. One way to get a rough estimate of the predicted maximum is to subtract the age from the number 220. For example, a 40-year-old predicted maximum heart rate is about 180 beats per minute. Elevated heart rate is associated with elevated blood pressure, increased risk for hypertension, and, among hypertensives, increased risk for cardiovascular disease. Blood Pressure is a measure of the force that the heart uses to pump blood around your body

In our system, we considered medical parameters such as pulse rate, Oxygen saturation level in blood for detecting the drowning victim due to their high reliability. We also analyze the active movement of breathing by monitoring the inhalation and exhalation. Table-II is the inferred list of the medical factors and its abnormalities that are taken into consideration.

TABLE II

Medical, electrical and general features

Medical parameter	Abnormality range
Pulse rate	< 60 BPM or > 125 BPM
SPo2 level	< = 90 %
Inspiration pressure	Zero for > 30 seconds

On measuring Pulse Rate, if the victims pulse rate exceeds above 125bpm, it is considered as abnormal and rescue operation should be taken immediately. On measuring the Oxygen Saturation Level in blood (SPo2), if the victims SPo2 level falls below or equal to 90%, it is considered as abnormal and rescue operation should be taken immediately. And in case of analyzing the active movement of breathing, we measure the inhalation and exhalation pressure. If there is the extreme difference or if there is an absence of measurement of pressure for the longer duration (30 seconds), it is considered as abnormal and rescue operation should be taken immediately.

B. Rescue Analysis

The system relates to a water floatation garment, and in particular, to such a swimming garment incorporating fillable bladder and electronics provided to identify emergency situation such as drowning based on sensed data that causing the garment to trigger the fillable bladder to inflate allowing a user to float to surface therein preventing a drowning. The main principle behind the floating of the person is that, when an instant release of air is triggered out from the wristband, the balloon is inflated instantly and will drag the drowning person to the surface of water. The air pump works well if a 24g CO2 cylinder is connected along with it to make it function underwater.

V. SIMULATION

Before implementing the working of the project, a virtual display output was simulated using a circuit simulation tool called Proteus design tool and the microcontroller was virtually embedded with its programming language using a programming compiler called Arduino Integrated Development Environment (IDE). The Arduino program will be compiled and the hex file will be bought into Proteus circuit, thereby, embedding the hardware and software for it to function as per the required instructions. The overall simulation was performed by integrating all the components along with the input and output instruments. The output rescue triggering system was the replaced with a green and red LED to check the proper functioning of the system. The results obtained exactly matched the individual simulation results, thereby, successfully completing the virtual implementation, circuit design and simulation. Fig-8 shows the circuit design and the output of the setup.

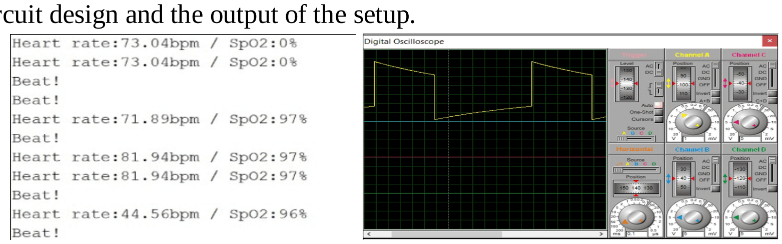

Fig. 8 Simulation Result of Overall System

VI. REAL TIME IMPLEMENTATION

The expected simulation results directly led to the real time implementation of the project using physical hardware devices. The circuit was constructed based on the simulated circuit taking all the hardware electronic components into consideration. The following interfaces were made:

A. Interfacing Heartbeat pulse sensor with OLED module to display BPM
B. Interfacing Pulse oximeter with LCD to display the SpO2 and Oxygen level
C. Interfacing Pressure sensor to display the inspiration pressure of the swimmer
D. Defining the BPM calculation, Heartbeat Detection and Oxygen level measurement.

Fig-9 and Fig- shows the output of the real time implementation of the project.

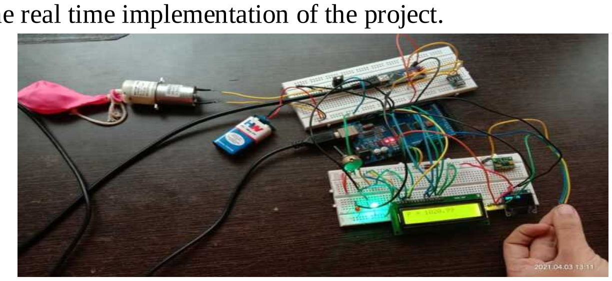

Fig. 9: Implementation of The Overall System under normal condition

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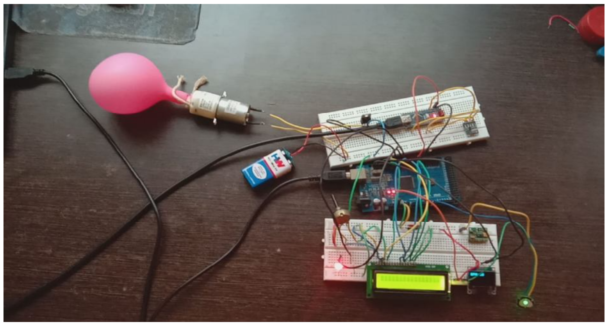


Fig. 10: Implementation of The Overall System under abnormal condition

VII. ADVANTAGES

The proposed drowning detection and rescue system will be useful in various ways. There is no requirement of internet connection for the device and hence can be used at any part of the world. It is battery operated and can be reused any number of times. The system includes minimum amount of user interface as it is fully automated and this would lead to instant response, thereby, saving the victim at the moment of drowning. The body parameters and its abnormalities of all swimmers irrespective of their gender, age and place of living are considered. Hence it is compatible to any swimmer which makes it feasible for anyone to buy. The alert system will indicate the people nearby that there is a risk of drowning and that will bring in additional rescue system to bring the victim to the shore.

VIII. FUTURE SCOPE

The simulation and implementation of the system provided a significant outcome to be considered in the next level of the project. Time is an important factor for rescue operation and hence, the efficiency and instant response of the air pump must be considered when the swimmer is underwater. The entire setup must consume less power to make it highly durable and to increase its lifetime. The air cylinder must be replaceable and the airbag must be reusable. And as a final note, the placement of every sensing device must be considered in order to sense the body parameters properly and provide accurate results.

IX. CONCLUSION

The comparative and comprehensive study of an automatic drowning detection and rescue system instigated a better technique of saving a life using a simple system. The increase in annual death rate due to incidences of drowning might well be reduced considerably with the help of this system. The provision of both drowning detection and rescue system is more suitable and can be a wearable device for all swimmers. The need of the hour is to make people be aware of the risks involved in swimming and be conscious enough to wear a safety device.

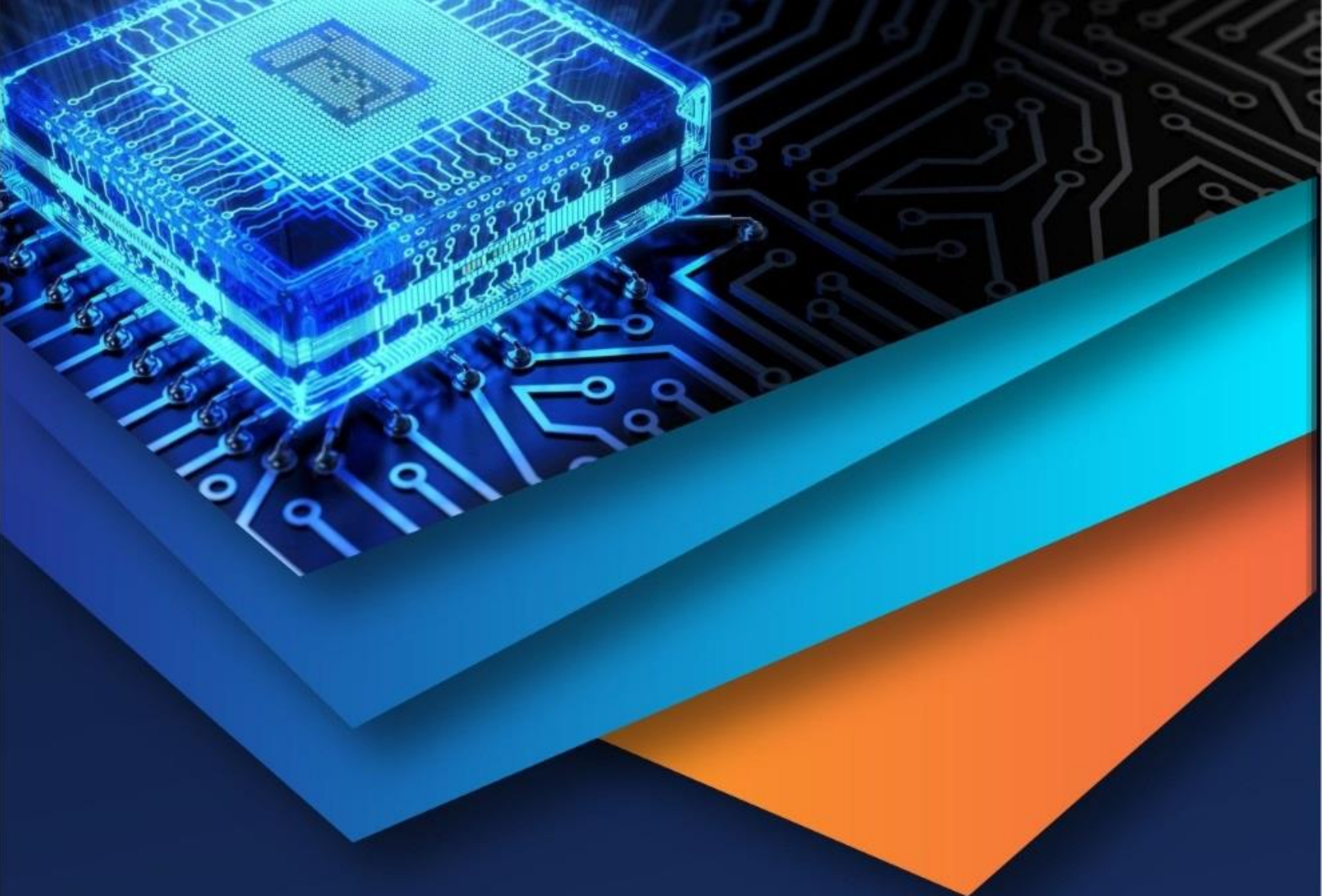
REFERENCES

[1] Alvin H. Kam, Wenmiao Lu, and Wei-Yun Yau '*A video-based drowning detection system*' Centre for Signal Processing, School of Electrical and Electronic Engineering, Nanyang Technological University.

[2] Captain Roger H Fuller MC '*The clinical pathology of human near-drowning*', USN Armed Forces Institute of Pathology, Washington, D.C., U.S.A.

[3] Fredrik Koller Lund, Johan G R Torgersen and Hans Kristian Flaatten '*Heart rate monitored hypothermia and drowning in a 48-year-old man. survival without sequelae: a case report*', Cases Journal 2009.

[4] International Journal of Mechanical Engineering and Technology '*Design of a drowning rescue alert system*' volume 10, Issue 01, January 2019.



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