Webology (ISSN: 1735-188X)
Volume 18, Number 5, 2021

Automation Of Swimming Pools To Prevent Drowning Deaths Using Iot , Sensors And Unique Algorithm

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ABSTRACT:

Technology is day by day assuring life security and safety. But the preventable accidents not coming in control despite several methods and devices in use. The current paper discusses and addresses the issue with accurate and reliable methods. In this article showing how the Sensors and programmable devices with intelligent algorithm has resulted in an efficient and improved system to provide safety and security around the swimming pools . The experimental results and observations revealing extremely dependable solution to the proposed problem. With the presented methods, more safety is assured to toddlers, patients with seizures, and semi-skilled swimmers etc.

Keywords- Power-on-self test, anti-Drowning, Drowning-prevention, sensor array, autonomous rescue, Arduino, life-saving.

1. Literature on existing methods:

"World health organization" (WHO) statistics reveal that nations throughout the world are strongly advised to adopt accurate, trustworthy methods to counteract the rising death toll due to drowning. The WHO estimates that there are 3.72 million deaths every year, and the number is increasing at an unacceptable rate. Over 40 people per day die needlessly as the result of unintentional deaths, which can be prevented if effective measures are taken. There are scarcely any preventive measures implemented in India to decrease the risks [17][18].The Fig.1 below shows clearly why a precise device is vital in order to protect people from the said danger. If we see the situation in INDIA, there are almost no preventive measures implemented to cut back the danger [17][18].

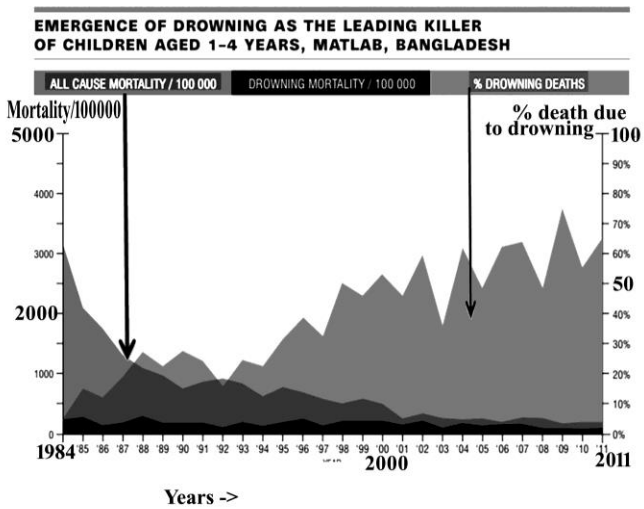

Fig.1 WHO statistics on Drown Deaths

In a drowning situation, the victim will desperately try to call for help, but unfortunately, the victim's mouth is blocked with water making it impossible for the victim to cry or shout for help. Tragically, the drowning death can occur within minutes[1]. Clinically the water side accidents are classified into 2 types "passive “and "active drowning [3]. An unconscious victim of passive drowning could also be suffering from any serious medical problem that renders them dead. The swimmer is either inexperienced or falls in the pool by accident. Passive drowning occurs when there is no supervision or if the swimmer is not properly trained. Many conventional community pools use specific techniques, including underwater cameras, buzzers [4], where some person must sit in the control room to keep an eye on everything. The paper by Hanbing Liu et al [13] consists of a framework that takes advantage of dedicated cameras and DSP engines to build alerts based on swimmer motion analysis, but this system lacks an autonomous rescue mechanism. Aida Carballo-Fazanes et al [15] have given a study on swimmer motion while encountering a risk in a swimming pool. The journal by Mr. Lin, CY., Wang, LY [19], in certain countries like South Africa, Guyana, Morocco, Houtamalla, and India, the death rate is heart-melting and makes anyone sad few countries such as Austria, Portugal, Austria, Netherlands, Denmark, Korea, etc somehow managed to reduce deaths significantly. By integrating sensors with an embedded processor, A. Kulkarni [20] developed another system based on an embedded algorithm for alerting in drowning situations. The method given in the reference [4] is a wearable device with an airbag linked with a pressurized tank and airbag is blown based on the sensor data and motion estimation program in embedded processor Another reference [6] is a type of wrist band gadget to report a panic alert based on the blood pressure which needs proper learning and calibration and subject to false alarm; and similarly another wearable in reference [12] works with a heart-beat sensor. The author of reference [11] has presented an auto-drown detect gadget with an RF tag accompany with a GSM-GPS module to locate and alert an accident in the pool. None of the devices are providing autonomous multilevel detection, protection, and rescue.

2. Proposed solution to the defined problem:

The proposed system comprises an elevator, proximity sensors, serially connected push buttons, Laser-trip wire arrangement, alerting buzzers, RED colored lights, drain motor with few intelligently programmed Master-Arduino processors, and Nano-Arduino-Processors. The sidewalls and bottom walls (i.e elevator surface) are mounted with an intelligent sensor network and accessible push-to-break switches to monitor and assist swimmer in drowning condition. The elevator and drain motor is the depth controlling elements and the remaining are used for alerting the drowning incident and system health. The proposed system manages to use swimming pool surface just like the ordinary office space when not in use situation.

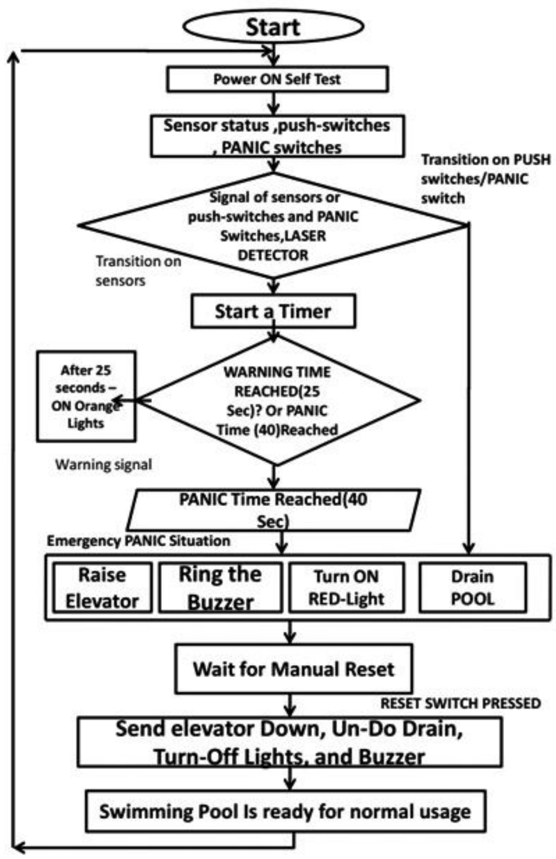

Fig.2 Flow-chart of the proposed system

The system uses a flat-elevator (with apertures to help water to flow either sides) .whose position is decided by the sensor outputs, and swimmer decision where ever the swimmer/user stands. The elevator surface is acting like the bottom surface which controls the depth of the swimming pool while the swimmer is swimming and can raise its position when the swimmer decides or the system detects a drowning incident or someone initiates a rescue operation by pressing panic-switch (push to break switch) outside the swimming pool(Part.No.3 in Fig.3).

The present paper discloses a novel algorithm and implementation of the complete framework. The proposed framework follows the flow chart shown in Fig.2. Fig.2 shows the start of the system will initiate the Power-On-Self-Test process where all the sensors, the position of the devices and alerts the user by glowing RED lights around the swimming pool so, the user understands the level and status of the security system and decides either to use or avoid the swimming pool. A manual reset (Part No-4 in Fig.3) is to halt all the ongoing processes and initiate a power-on-self test procedure immediately mainly useful in the event of a false alarm.

2.1 Multilevel Rescue:

The complete electrical connection block diagram is shown in Fig.3 which include

1.ArdiunoUno labeled as Master-Arduino with the program described in flowchart Fig..2.
2. Several Nano-Arduino boards interfaced with proximity sensors(MB1001**)** and Laser-Trip-wire arranged(KY-008) on elevator surface(acting as swimming pool bottom)Fig.4&5.
3. Motor [L293D] driven Screw-Jack bearing elevator surface.Fig.6.
4. Buzzers and RED-colored lights.
5. Control panel with basic swimming pool controlling function switches.

The wireless communication module is there to activate/ring the wireless communication module which is a buzzer in the hands of security persons to indicate the occurrence of ongoing drowns rescue operations to seek medical attention. The series of orange lights (part no-17 in Fig.3) are used to indicate the heath of the swimming pool after the Power-On-Self-Test procedure. A readily available transceiver inside the walkie-talkie is used as a wireless communication device in the proposed system. The control panel has basic function keys such as RESET, Power-On, Empty-poor(Drain) etc.

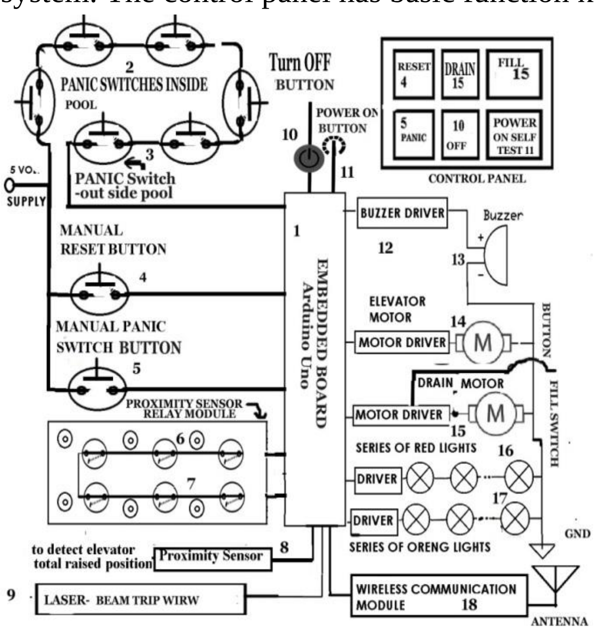

Fig.3 Electrical Connection diagram of the system.

Level-1: Autonomous Rescue:

The proximity-sensors (Fig.5) and Laser-trip-wire (Fig.4) were properly connected to Nano-Arduino processors with a delay counter program. These sensors and nano-Arduino are destined to sense the arrival and staying of any object close to them and start a counter to measure the time of consistent stay of the object and give an alert (Part.No.6&9 in Fig.3) if the stay time exceeds threshold. As soon as the object stays longer than the preset number of seconds (like 50 seconds) and gives a signal alert to Master-Arduino to take the decision.

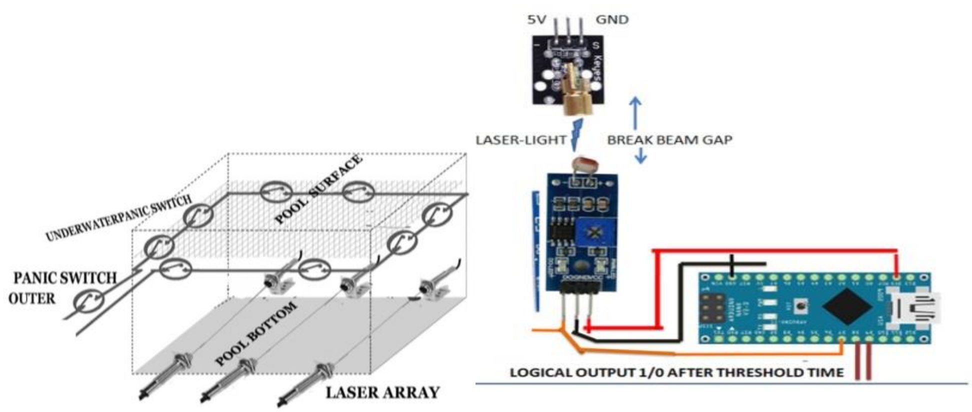

Fig.4 Laser Tripwire connection in swimming pool bottom with push-to-break switches underwater.

The system assumes stable and proper working condition, only when the laser trip-wire and proximity sensors associated by nano-Arduino processors sensing nothing on the swimming-pool bottom and checks continuously for any occurrence of a human body or any object .The system is ready to alert the master-Arduino-processor if something staying wrongly on the surface of the swimming pool bottom for longer than the threshold time.

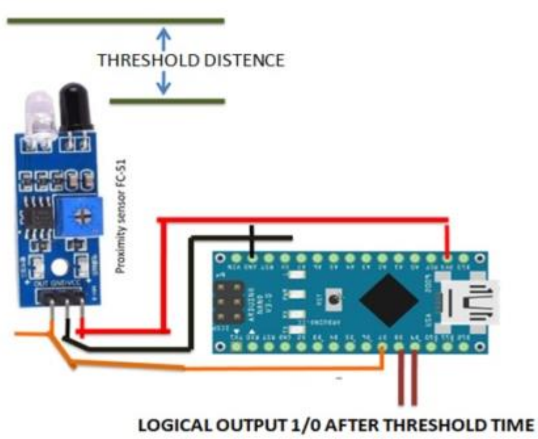

Fig.5 Arrangement of proximity sensor Laser-Trip-Wires and connection diagram of the proximity sensor

Level-2 Swimmer Assisted Rescue:

The swimmer-assisted rescue is another level of security, where several push-to-break(Part.No.2 in Fig.3) switches were connected serially and connected to Master-Arduino. These push-to-break switches are mounted on all side walls and surfaces of the elevator which are accessible to the swimmer when submerged deeply underwater. The swimmer can push any switch which creates a broken connection to Master-Arduino and the Master-Arduino will assume a definite drown situation and activates all alerting and auto-rescue operations explained above immediately.

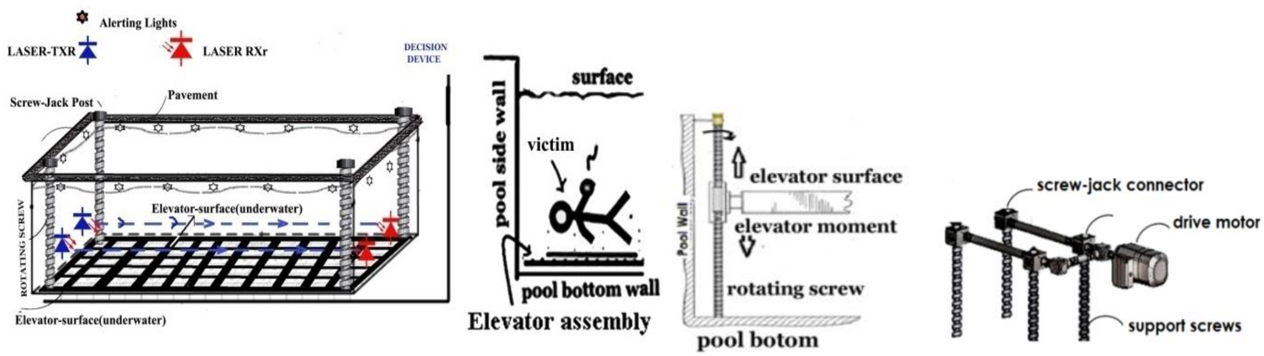

Fig.6 3-D swimming pool and screw-jack motor assembly

Level-3 Observer-Assisted Rescue:

There are similar push-to-toggle (break) switches outside the swimming pool (Part.No.3 in Fig.3) accessible to people around the swimming pool so any non-swimmer also can save a person in risky conditions without jumping into pool. These push-to-break switches are helpful when the swimmer fails to push the toggle switches underwater and, the sensors fail to sense the drown situation, and if anyone watching the swimming pool(a non-swimmer) can also trigger a rescue by pressing these toggle switches. These switches will make the master-Arduino initiate the immediate rescue procedure.

Level-4 Power-On-Self-Test:

This is an intelligent program that moves the elevator from top to bottom twice, checks the status of sensors, and control switches (push to break switches). This feature is performed every time the system is powered on to check the health of the system (Fig.2) and gives confidence to the swimmer.

Level-4: Idle Condition:

The swimming pool pavement is fitted with a motion sensor to detect the moment water is in motion. When it is absolutely motionless for 5 minutes the master Arduino will shut off the system (by raising the elevator to the top position firmly) to prevent anything from falling in the pool.By enabling this feature, unauthorized entry, accidental falling of pets and kids in idle conditions will be prevented.Fig.6 shows the 3D model of the swimming pool framework with a screw-jack elevator.

3. Experimental Results & Discussion

A prototype was created and tested at several occasions to check its endurance and responsiveness. The prototype worked exactly as described in a flowchart. In a controlled environment, a prototype of the proposed product is built, tested for security and safety in a variety of lighting conditions, and calibrated for varying purity levels of water. The Fig.7 is the framework used as an active elevator comprising all features and is tested by submerging in large water vessel. To reach the surface on time, the actual system must incorporate powerful elevator motors with tuned speeds.

Table.1 has the results of the experiments at various conditions. It clearly showing lighting has the minimum effect on the performance of the design.

Table.1: Experimental Results based on Lighting Conditions

Lighting Condition	**Laser Sensor** Working	**Proximity sensor**	**Final Result**
Daylight	Yes	Yes	Best
Fluorescent Bulb Lighting (Day)	Yes	Yes	Best
Fluorescent Bulb Lighting (Night)	Yes	Yes	Satisfactory
Moderate Lighting(Evening)	Fair	Yes	Fair
Full Dark	Fair	Yes	Fair

Table.2: Experimental Results based on Water purity Conditions-20 iterations.

Water Quality	**Laser Sensor accuracy**	**Proximity sensor Working**	**Final Result**
Clearwater	Working	Normal	Fair
Medium-dark color water	6% failures	Normal	Fair
Very dark color water	60% failure	Normal	Satisfactory,

Warm water(20 degrees)	1% Failures	Normal	Acceptable
Warm water(40 degrees)	1% failures	Normal	Acceptable

Clearly the table-2 shows that the color(purity) of the water will affect the performance of the proposed system, although it is still reasonably effective.

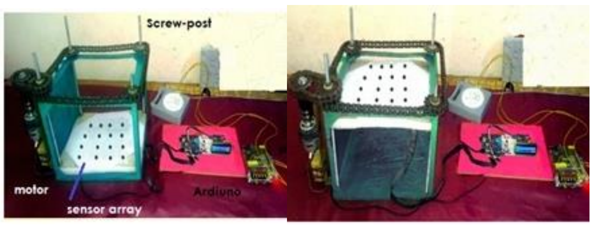

Fig.7: Prototype, showing elevator lowered and raised position without water

3. Proposed Method Advantages

The advantage of the system is that swimmers do not have to be watched over because it has an autonomous rescue feature. The present system does not require any wearable gadget and is completely independent from wearable safety devices. Since the sensors utilized are durable, the proposed system provides more confidence to swimmers. The idle condition, which is described, prevents accidental injury to children, animals, and even dirt in case of an unattended pool. When arranged inside a building, an idle swimming pool can function as a normal floor for a home or office, saving the cost of unoccupied space. In general, swimmers are afraid of drowning and suffocation, which will accelerate the depletion of oxygen in their bodies, so the proposed system provides a method for them to no longer have this fear. The table.3 has given performance comparison with respect to existing systems and the proposed system.

Table.3 Comparison of existing systems in references and the proposed system

S. No	**Ref No's of existing systems**	**Sensing Method**	**Mode of action**	**System complexity**	**Cost efficiency**	**reliability**	**False Alarm**

1	PROPOSED SYSTEM	PROXIMITY, LDR, SWITCHES	AUTONOMOUS, MANUAL	MODERATE	ECONOMIC	MORE	LOW
2	Ref No [4]	Acceleration, pressure sensor	Detection and rescue	Moderate	Moderate	Moderate	High
3	Ref No [5]	Image Processing	Detection and alarm	High	Low	Moderate	Moderate
4	Ref No [6]	Pressure sensors	Detection and rescue	Low	High	Low	Low
5	Ref No [12]	Heart Beat Sensor	Detection and alarm	Moderate	High	Moderate	Moderate
6	Ref No [11]	RFID	Detection and alarm	Low	Moderate	Moderate	High

4. Conclusion

There is no mention of an autonomous rescue or multilevel protection alerting system in the prior art, as described in literature and inventions. These security gaps are effectively addressed with fail-proof methods, hardware, and software algorithm implementation. Using multiple processors reduces computational load and enables quick decision making. The proposed system has demonstrated promising results, and it should be implemented in domestic swimming pools and public pools to prevent unintentional drowning deaths. Definitely the proposed system will attract the attention of parent who cares for their kids ,elders, and pets.

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Acknowledgement: Special thanks to Dr.Jithender Reddy, Professor in English for helping in language beautification.

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