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Aqua Blue Guard:Revolutionizing Pool Safety with AI and IoT

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Abstract
Abstract— In response to the growing number of pool accidents involving young children, a new safety system has been developed to enhance protection for kids aged 1-4, especially in busy pool settings where lifeguards may struggle to monitor everyone. This innovative system combines machine learning and image processing technology to detect potential drowning situations and respond instantly. An underwater camera constantly monitors the pool, using image processing to recognize signs of distress. Connected to a central Raspberry Pi, the camera communicates with an Arduino Nano that controls a mesh designed to lift a child out of the water if needed. If the system identifies a potential drowning, it activates the mesh and sounds a buzzer to alert nearby individuals. By adding this proactive layer of safety, the system provides real-time support to lifeguards, aiming to improve overall safety for young swimmers in high-risk pool environments.
Keywords: Drowning prevention,Smart safety systems,Child safety, Real-time monitoring, Arduino Nano,Raspberry Pi, Automated drowning detection, Lifeguard assistance

1. INTRODUCTION

Swimming pools are a great place for fun and relaxation, but they also come with serious safety risks, especially for young children. Despite the best efforts of lifeguards and existing safety measures, pool accidents and drownings still happen, particularly in busy or crowded pools. Traditional safety methods often struggle to detect and respond quickly to emergencies, highlighting the need for better solutions. To address this problem, we propose a smart safety system that uses modern technology like machine learning, Arduino Nano-controlled nets, and a central control hub powered by Raspberry Pi. This system is designed to improve the detection of emergencies and provide faster responses to potential dangers in swimming pools. The machine learning aspect can spot unusual activity or risky behavior in the water, while the Arduino-powered nets can act quickly to help prevent accidents. The Raspberry Pi acts as a hub to coordinate all these parts for efficient monitoring and response. However, building and using this kind of system in real-world pools comes with challenges. It needs to be reliable, adaptable to different types of pools, and easy for people to trust and use. Continued testing, refinement, and collaboration with experts are essential to make sure it works as intended in various situations. As pool accidents remain a serious issue, creating more effective safety systems is crucial. Using smart technology offers a chance to significantly reduce risks and create safer swimming environments. With further research and development, we can give everyone more peace of mind when enjoying time at the pool.

2. Methods of Sign Language

The smart swimming pool safety system works by continuously monitoring the pool for any signs of distress. It uses an underwater camera to capture real-time footage of the pool, while a motion sensor detects unusual movements in the water, like splashing or stillness. The camera sends video to a small computer called a Raspberry Pi, which uses special software to analyze the footage. If the camera detects a child struggling or staying underwater too long, and the motion sensor confirms unusual activity, the system triggers an automatic response. The system activates an underwater mesh that inflates and lifts the swimmer to the surface, providing quick assistance. At the same time, an alarm and flashing lights go off to alert nearby lifeguards, pool staff, and bystanders of the emergency. Push notifications are sent to lifeguards' mobile devices, giving them immediate updates and access to the live video feed, so they can assess the situation. This combination of real-

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time monitoring, automatic intervention, and human alerts ensures that drowning incidents are detected and responded to as quickly as possible. The system also logs all events for review and improvement, helping to ensure better safety in the future.

Table 1: Major System Components and Their Functions

Component	Purpose
Underwater Camera	Captures real-time pool footage
Raspberry Pi	Processes video data using AI algorithms
Motion Sensor	Detects abnormal water movement
Arduino Nano	Controls automated rescue mechanism
Underwater Mesh	Lifts swimmer to water surface
Alarm and Buzzer	Alerts nearby individuals
Connectivity Module	Sends alerts and stores monitoring data

3.Components

3.1.Alarm and Buzzer System

The alarm and buzzer system is designed to alert lifeguards, pool staff, and bystanders to the emergency situation. Once the system detects a drowning incident, it activates a loud siren or buzzer to provide an immediate audible warning. The sound ensures that people in the area are quickly made aware of the situation, allowing them to take appropriate action, such as performing a rescue or administering first aid. Additionally, flashing lights or strobe lights may be triggered, providing a visual indication of the emergency, which is particularly useful in noisy or crowded environments. This alert system plays a crucial role in facilitating fast responses from those nearby

Fig 1 Alarm and buzz

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3.2.Motion Sensor

In addition to the camera, a motion sensor provides a secondary layer of detection to confirm the presence of a potential emergency. The motion sensor (commonly a PIR or Passive Infrared sensor) detects sudden movements or irregular activity in the pool area, such as erratic swimming or a swimmer's sudden stop, which may signal a problem. In certain configurations, ultrasonic sensors or accelerometers could be used to detect disturbances in the water itself. By combining the camera's visual input with the motion sensor's data, the system can reduce false positives and increase the accuracy of detection, ensuring that only legitimate emergencies trigger a response.

Fig 2 Motion Sensor

3.3.Raspberry Pi

The Raspberry Pi acts as the central processing hub for the entire system. It interfaces with both the camera and the motion sensor, processing the inputs and running the necessary algorithms to identify potential drowning scenarios. This single-board computer runs on Linux-based operating systems, such as Raspbian, and provides has enough processing power to smoothly handle real-time video analysis.. It communicates with other system components, such as the alarm and mesh activation mechanisms, to trigger responses when necessary. The Raspberry Pi also stores any captured images and video feeds for review or later analysis.

Fig 3 Raspberry Pi

3.4. Underwater Mesh (Automatic Lifting Mechanism)

The underwater mesh is a key physical component of the system, designed to provide immediate assistance to a distressed swimmer. When the system detects a drowning emergency, it triggers an automatic mechanism that deploys a mesh net underneath the water. This mesh is made of durable, flexible material that can quickly lift the swimmer to the surface, allowing for easy retrieval. The mesh is inflated using a pneumatic air bladder or pump system, which rapidly inflates when activated by the system's sensors. This mechanical intervention ensures the swimmer is brought to the surface without relying solely on human intervention, potentially saving valuable time.

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Fig 4 Underwater Mesh

3.5.Flowchart

The flowchart explains how the proposed swimming pool safety system works to protect children from drowning. It starts with an underwater camera that constantly monitors the pool and detects if a child is struggling or in danger. To ensure accuracy, a motion sensor also checks for unusual movements to confirm if it is a real emergency. If a problem is detected, two actions happen at once: a safety net lifts the child to the surface, and an alarm and buzzer go off to alert nearby people to help. This approach combines fast automatic action with human assistance for effective safety.

The system starts by keeping a constant watch underwater using special cameras. These cameras are used to spot anyone who might be drowning by analyzing their movements through image processing. If someone is staying still for too long or showing signs of struggling, the system takes notice. To make sure the situation is serious, motion sensors are also used to check if there's any physical movement. If both the camera and sensor data suggest that someone might be drowning, the system confirms it as an emergency. Once confirmed, it quickly takes action in two ways: it activates a safety net underwater to stop the person from sinking further, and it also sets off alarms and buzzers to alert nearby people.

Finally, trained human rescuers are sent to the spot to help and perform the actual rescue.

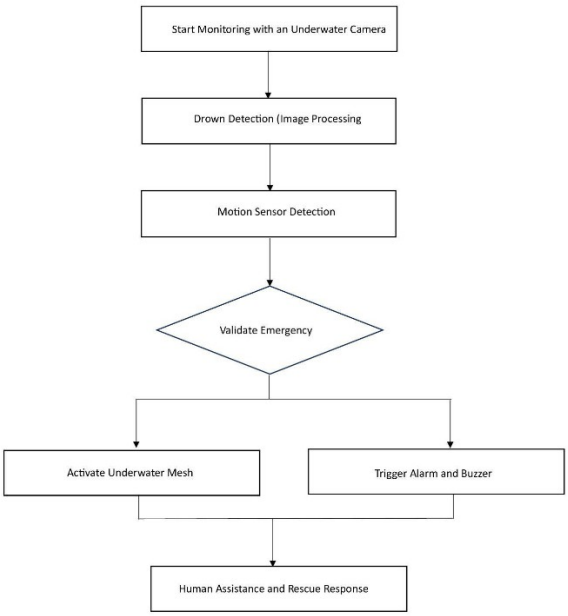

Fig 5 Flow chart

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4.RESULTS AND DISCUSSION (12 pt)

4.1.Results

The Aqua Blue Guard system was tested to evaluate its ability to detect potential drowning situations in a swimming pool environment. The image processing module successfully identified abnormal swimmer behavior such as prolonged submersion and irregular movement patterns.

The combination of camera monitoring and motion sensor detection helped reduce false alarms while improving detection accuracy. When a potential emergency was detected, the automated rescue mesh responded quickly by lifting the swimmer toward the surface. At the same time, the alarm and buzzer system alerted nearby individuals for immediate assistance.

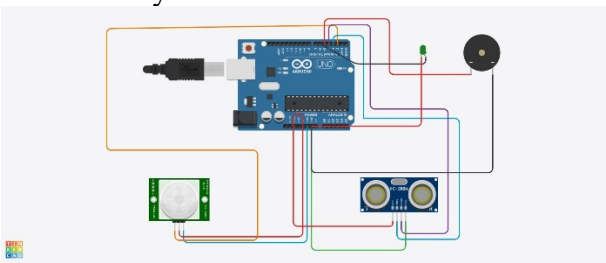

Fig 6 model

4.2.Discussion

The experimental results indicate that integrating AI-based monitoring with sensor validation can improve swimming pool safety. Continuous video analysis enables the system to detect risky situations faster than traditional monitoring methods.

Although the system performed effectively, environmental factors such as lighting conditions and water disturbances may influence detection accuracy. Further improvements using advanced machine learning techniques can enhance system reliability in real-world pool environments.

CONCLUSION

This research presented **Aqua Blue Guard**, a smart swimming pool safety system that combines artificial intelligence, IoT devices, and automated rescue mechanisms to prevent drowning incidents. The system uses an underwater camera, motion sensor, Raspberry Pi, and Arduino Nano to detect dangerous situations and respond quickly.

By providing real-time monitoring, automated assistance, and emergency alerts, the proposed system can significantly improve swimming pool safety. With further development and real-world testing, Aqua Blue Guard has the potential to become an effective technological solution for drowning prevention.

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