Saving Lives At Sea: An Automated Drowning Rescue Technology

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Abstract— **Drowning is a pressing global issue, responsible for 7% of unintentional injury deaths worldwide. To address this challenge, we proposed An Automated Drowning Rescue Collar, a technologically advanced solution equipped with GPS, accelerometers, and gyroscopes for precise location tracking and depth assessment of individuals in distress. Our research encompasses a comprehensive implementation plan, from design and material acquisition to prototype manufacturing, testing, documentation, and final product development. Powered by solar energy, the Automated Drowning Rescue Collar aligns with Oman's sustainability goals and exhibits versatility for various sectors, including aviation, marine, and military applications. The benefits to Oman are substantial, including the potential to save lives, reduce drowning incidents, and support rapid deployment and supply transport. This research harmonizes with Oman's vision for technological innovation and sustainable progress. In conclusion, the Automated Drowning Rescue Collar offers a cutting-edge, eco-friendly, and adaptable solution to the global drowning epidemic. Through advanced technology and renewable energy, it holds the promise of safeguarding both rescuers and individuals in peril, thereby making a significant contribution to water safety on a global scale.**

Keywords— Drowning Prevention, Automation, IoT, Water Safety, Technological Innovation, Sustainable Rescue

I. INTRODUCTION

Drowning is an ever-present and significant global issue, ranking as the third leading cause of unintentional injury deaths worldwide and contributing to a staggering 7% of all such fatalities [1]. Annually, an estimated 236,000 lives are tragically lost to drowning, underscoring the urgency of this pervasive concern [1]. What makes this problem particularly distressing is its indiscriminate nature, affecting individuals of all ages and backgrounds. Despite the remarkable technological advancements witnessed across numerous sectors, drowning prevention and rescue have regrettably lagged behind [2]. It is within this context that a novel and proactive approach is imperative – one that harnesses technology to efficiently save lives while minimizing unnecessary risks to rescuers. At the heart of this study lies the fundamental research problem: how can we effectively address the global drowning crisis and provide timely aid to those in peril without further jeopardizing the lives of rescuers? To address this pressing issue, our research endeavours to introduce the world, the Automated Drowning Rescue Collar – an innovative and groundbreaking device poised to revolutionize drowning rescue operations [3]. The overarching purpose of our research is to conceive, develop, implement, and rigorously test the Automated Drowning Rescue Collar – a cutting-edge technology explicitly designed for drowning rescue operations [4]. Our primary objectives are multifaceted and driven by the desire to leverage modern technology for the betterment of society. We aim to reduce the inherent risk associated with rescue efforts, bolster the probability of saving multiple lives simultaneously, and provide a dependable and efficient means of conducting drowning rescues. In essence, the Automated Drowning Rescue Collar seeks to honour the unwavering dedication of rescue professionals and, above all, save lives both efficiently and safely in the face of a global crisis.

Inspiration from Oman's Vision 2040

Our project is deeply inspired by His Majesty Sultan Qaboos bin Said Al Said's vision for Oman in 2040, which places significant emphasis on innovation and technology. This vision serves as the driving force behind our endeavours, motivating us to explore innovative solutions to address the global drowning crisis and, in doing so, pay tribute to the unwavering dedication and sacrifices of our heroes from the civil defence, Royal Oman Police, and the Ministry of Defence. These exceptional individuals have wholeheartedly committed themselves to the noble cause of saving lives, often placing their own well-being at risk to achieve this mission. Our commitment to this project is a testament to our collective desire to honour their dedication and contributions to society.

In the following sections, we will delve into the intricate details of our research methodology, the innovative design and mechanisms of the Automated Drowning Rescue Collar, the materials and technology that constitute this groundbreaking device, as well as a comprehensive discussion of the results, implications, and potential future directions for this transformative project. Through this journey, we aim to shed light on the profound impact that technology can have in safeguarding both rescuers and individuals in peril, making a significant contribution to water safety on a global scale.

A. Problem Statement

The World Health Organization, in collaboration with an array of authoritative bodies and organizations, consistently highlights the sheer magnitude of the drowning crisis that looms worldwide. Evidencing the gravity of this global concern, UNICEF has published a guide replete with over 125 references, drawn from diverse corners of the world [5]. This comprehensive compilation, documented by the Department for Management of NCDs in 2017, underscores the urgent need for intervention. In the face of imminent danger posed by drowning incidents, whether in civilian or military contexts, a league of highly trained professionals emerges as the frontline heroes. Time and again, they embark on dangerous rescue missions with unwavering dedication [6]. However, their noble endeavours come fraught with severe risks, and tragically, these heroes sometimes pay the ultimate price for their valour.

This ambitious project aspires to revolutionize the way lives are saved, steering clear of imperilling the valiant rescuers. Through the ingenious amalgamation of cutting-edge technology and sustainable green energy solutions, it endeavours to provide a lifeline to those at risk while safeguarding the lives of those who rush to their aid. In doing so, its ushers in a new era where the perils associated with drowning are significantly mitigated, and a brighter, safer future is within reach

B. Objectives

Our foremost goal is to harness contemporary technology to effectively minimize the inherent dangers associated with drowning incidents, prioritizing the safety of those entrusted with the vital task of rendering assistance. However, our ambitions extend further, aiming to elevate the capacity to rescue multiple individuals concurrently. The development of the Automated Drowning Rescue Collar brings forth a myriad of advantages, notably encompassing the prevention of the potential loss of highly skilled professionals during demanding rescue missions. Simultaneously, it empowers us to conduct rescues with the utmost safety and professionalism, assuring that lives in peril are saved with the highest level of care and efficiency.

In essence, our research serves as a beacon of hope in the realm of drowning prevention and rescue. It seeks to bridge the gap between the pressing global crisis of drowning incidents and the technological innovations that have revolutionized numerous sectors. By introducing the Automated Drowning Rescue Collar, we aspire to fundamentally alter the landscape of water safety, drawing inspiration from His Majesty Sultan Qaboos bin Said Al Said's vision for Oman in 2040. This vision, rooted in innovation and technology, provides the impetus for our project, honouring the unwavering commitment and sacrifices of our heroes from the civil defence, Royal Oman Police, and the Ministry of Defence.

Ultimately, the Automated Drowning Rescue Collar embodies the fusion of technological prowess, sustainability through solar energy, and the promise of swift and efficient responses to water-related emergencies. It symbolizes a quantum leap forward in the field of drowning prevention, offering a lifeline to those in dire need while safeguarding the lives of our courageous rescuers.

II. METHODOLOGY

The Automated Drowning Rescue Collar embodies a circular, lightweight design, meticulously crafted from buoyant plastic material. Its construction incorporates waterproof compartments, ensuring that it remains resilient even in challenging aquatic environments. Within its structure, a receiver sensor plays a pivotal role in detecting signals transmitted by the wristband when submerged, guiding the collar to the person in distress. Moreover, the collar houses dedicated storage compartments, meticulously sealed to safeguard the contents, which include essential first-aid equipment and survival supplies. These provisions are indispensable in ensuring the well-being of the individual awaiting rescue.

Complementing its life-saving capabilities, the Automated Drowning Rescue Collar integrates a VHF transmission and receiving system, which serves as a robust communication platform connecting the device with the Civil Defense. This feature enables real-time communication and reporting, streamlining rescue efforts. A critical component of the collar's functionality is its battery-powered water jet thrust system. This system not only aids in propelling the injured person to safety but also optimizes their mobility, making their journey less arduous.

The collar's semi-foil shape is designed to enhance manoeuvrability, enabling it to navigate efficiently through water currents and swiftly reach those in need. Additionally, a built-in display unit provides vital information, including proximity to nearby shores and other critical data.

Innovative Technology and Green Energy:

The Automated Drowning Rescue Collar represents a paradigm shift in the realm of drowning rescue. Fuelled by sustainable green energy, it stands as a beacon of innovation and hope. Its intricate design and multifaceted functionality make it a promising solution to address the pressing global issue of drowning-related fatalities.

A. Working Mechanisms of the Collar

The Automated Drowning Rescue Collar operates through a trio of primary mechanisms, synergistically working together to ensure swift and effective rescue operations:

Remote Control: The Collar of Hope is equipped with a remote-control unit, allowing for manual control in diverse rescue scenarios. This feature enhances adaptability and precision during rescue operations.

Homing Device: The collar incorporates a sophisticated homing device that interfaces with the wristband worn by the distressed individual. Leveraging GPS technology, this device tracks the precise location of the person in peril and guides the collar to their position.

GPS-Based Location Tracking: In cases where the wristband's signal may be compromised, the collar relies on GPS technology for accurate location tracking. This redundant mechanism ensures that the collar can consistently locate and provide assistance to individuals in danger.

Understanding the intricate interplay of these three working mechanisms is pivotal to comprehending the Collar of Hope's capabilities fully. Figure 1 offers a visual representation of these

mechanisms, providing insight into how they synergize to locate and rescue individuals confronting life-threatening situations.
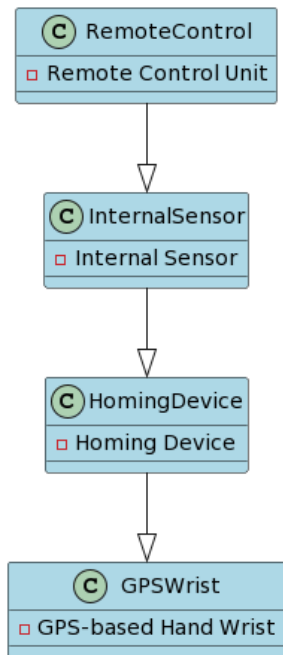

Figure1. An illustrative diagram depicting the three working mechanisms of the Automated Drowning Rescue Collar

III. LITERATURE REVIEW

The field of drowning prevention and rescue technologies has witnessed significant advancements in recent years, driven by the urgent need to address the global issue of drowning-related fatalities. Drowning ranks as the third leading cause of unintentional injury deaths worldwide, responsible for approximately 7% of such fatalities annually [7]. To combat this pressing concern, researchers and innovators have been actively exploring innovative solutions that leverage modern technology to enhance rescue operations, reduce risks to rescuers, and improve overall water safety. In this literature review, we delve into the existing body of research and technologies in the domain of drowning prevention and rescue, aiming to highlight the gaps, challenges, and opportunities that our proposed ' Automated Drowning Rescue Collar' seeks to address.

In [8] research introduces an automated vision-based surveillance system for detecting pool drownings. Using a Pixy camera, it tracks swimmers and deploys a linear stage with a hook to assist struggling swimmers. The system alerts lifeguards, aiming to reduce drownings, and future improvements include adding an infrared LED to swimmers' vests.

The study in [5]compared various anti-drowning and rescue systems, highlighting disparities in reliability, accuracy, cost, complexity, and usability. Image processing systems offer high accuracy but require substantial maintenance and installation costs. LASER-LDR is cost-effective but less accurate. RF transmitters and pressure sensing work on a small scale. RFID generates alarms but lacks automatic rescue capability. The

waist airbag system emerges as a cost-effective, reliable solution suitable for large-scale use, combining autonomous rescue and drowning detection in swimming pools.

The study in [9]compared diverse drowning detection and rescue systems, revealing variations in accuracy, complexity, and reliability. Image processing offers high accuracy but comes at a significant cost. LASER-LDR is cost-effective but less accurate. Pressure sensing and RF transmission work for pool rescues but not for large water bodies. RFID generates alarms in large water bodies but lacks rescue capability. The waist airbag system emerges as the most suitable, cost-effective, and reliable solution, providing both automatic detection and rescue.

The computer vision-based drone lifeguard system mentioned in [10] includes drowning detection, rescue drones, and hazardous activity detection components. It can detect drowning victims, dispatch rescue drones, and detect hazardous activities, assisting lifeguards. The system features an interface with sound alarms and an Android mobile service for notifications. Hardware limitations like a single camera and weather conditions affect accuracy but could be improved with multiple cameras and warnings for extreme weather conditions. Privacy is protected as all processing is client-side. Future enhancements could include additional cameras, a mobile app, and nighttime dataset collection for improved accuracy in low light.

This paper [11] presents an automated safety system for pools using Fourth Industrial Revolution principles. It operates autonomously, preventing drownings and accidents by monitoring pool surroundings and vital signs. Future work includes enhancing accuracy, and cost-effectiveness, and incorporating AI-powered image processing for abnormal behavior detection.

The study in [12] presents an affordable automated CPR device to address rising cardiovascular diseases in Bangladesh. While existing devices are costly, this solution, priced at $300, utilizes a DC motor and piston mechanism. Clinical trials have not conclusively demonstrated advantages over manual CPR, but the affordable cost makes it a viable option for emergency responders in developing regions. The device's size and weight limitations may be improved in future iterations.

Drowning is a global issue causing many deaths, especially in developing countries lacking safety measures. The drowning rescue system monitors heart rate and blood pressure, alerting rescuers to provide immediate help[13].

Swimming skills alone can't prevent drownings. An intelligent swimming pool design using a reliable algorithm and mechanical screw-jack ensures faster rescue, making pools safer and overcoming existing deficiencies[14].

The literature review in [15] compares drowning detection methods, emphasizing sensor-based and image processing approaches. While image processing offers high accuracy, it's cost-restrictive. Sensor-based methods are more affordable and adaptable, benefiting low-to-middle-income countries. Customization, AI integration, and motion tracking improvements are essential for sensor-based systems. Addressing these challenges can enhance water safety and prevent drowning incidents.

IV.   COMPARISON

Paper Title	Sensing Method	Mode of Action	System Complexity	Cost Efficiency	Reliability
Automatic Waist Airbag Drowning Prevention System	Accelerometer And Pressure Sensor	Detection and Rescue	Moderate	Moderate	High
Automatic Video-Based Drowning Detection System	Image Processing	Detection and Alarm	High	Low	High
Automated Drowning Detection And Security In Swimming Pool	Pressure Sensor	Detection and Rescue	Low	High	Low
Anti- Drowning System With Remote Alert Using Zigbee	Heartbeat Sensor	Detection and Alarm	Moderate	High	Moderate
Automatic Drowning Rescue System For Human Using RFID	RFID	Detection and Alarm	Low	Moderate	High

V. TECHNOLOGY AND MATERIALS USED

The Automated Drowning Rescue Collar incorporates advanced technology and materials to achieve its life-saving objectives. Key components include:
GPS Chip: This chip facilitates precise location tracking [16].
Accelerometer and Gyroscope: These sensors assist in depth assessment and direction determination [17],[18].
Solar Panels: Solar energy is harnessed for power, aligning with sustainability goals [19].
High-Grade Plastic Material: The collar and wristband are constructed from anticorrosive and waterproof high-grade plastic, ensuring durability and safety [20].
Emergency Features: The wristband includes emergency lighting, a whistle, and an electronic transmitter for signaling.
First Aid Kit: The collar contains compartments for first-aid equipment, essential for immediate care.
The combination of advanced technology and robust materials makes the Automated Drowning Rescue Collar a powerful and reliable tool for drowning rescue, capable of operating in various conditions and effectively addressing the global issue of drowning.

The success of the Automated Drowning Rescue Collar in saving lives relies heavily on the materials and components carefully chosen for its construction. Fig 2, titled "Materials and Components," presents a visual representation of the key elements that form the foundation of this innovative drowning rescue technology. From the GPS chip for precise location tracking to solar panels for sustainable energy, these components are meticulously integrated to ensure the device's efficiency and reliability.
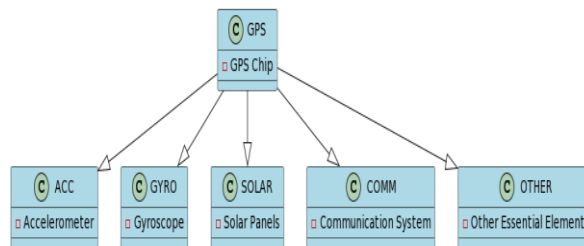

Figure2. Materials and Components - A visual representation of the key materials and components used in the construction of the collar and wristband

This Automated Drowning Rescue Collar is not just a technological marvel for locating and rescuing individuals in distress; it also offers a unique and vital capacity for carrying essential supplies and emergency signaling equipment. This figure showcases the compartments within the collar that house the first aid kit and flare gun. These compartments are strategically designed to ensure the safety and well-being of the rescued individual and to facilitate emergency signaling when needed.
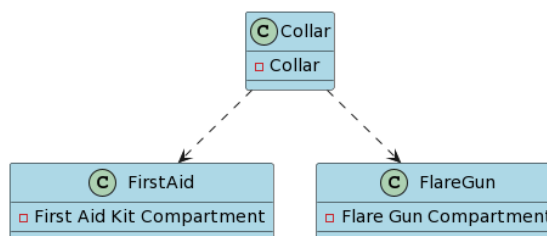

Figure3. First Aid Kit and Flare Gun Compartments - A diagram showcasing the compartments within the collar that house the first aid kit and flare gun

The illustrative diagram Fig 3 provides a visual representation of the compartments within the collar that hold critical supplies and equipment. It emphasizes the Automated Drowning Rescue Collar comprehensive approach to drowning rescue, addressing both immediate medical needs and emergency signaling.
Effective communication plays a pivotal role in successful drowning rescue operations, ensuring a seamless exchange of vital information between the person in distress and the rescue team. Figure 4, aptly titled "Communication System," offers an illustrative diagram that sheds light on the components responsible for facilitating this crucial aspect of the Automated Drowning Rescue Collar. This diagram provides a visual representation of the VHF transmitter and receiver, which serve as the backbone of the Automated Drowning Rescue Collar communication system. By examining this figure, we can gain insight into how these components work together to bridge the gap between individuals in distress and rescue teams, allowing for effective coordination and timely assistance.
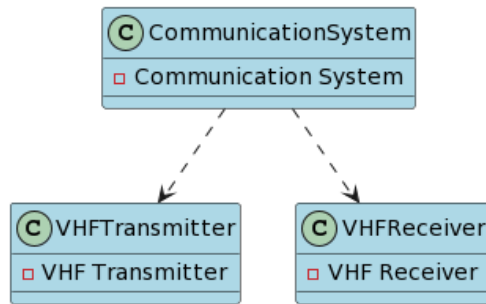
Figure4. Communication System - A diagram illustrating the communication system's VHF transmitter and receiver, showing how it facilitates communication between the person in distress and the rescue team

VI. CONCLUSION

The Automated Drowning Rescue Collar stands as a beacon of innovation and hope in the face of the global drowning crisis. This research journey, from inception to its culmination in a life-saving technology, has yielded significant insights and demonstrated the profound potential for technology-driven solutions in addressing pressing global issues.

Drowning, accounting for 7% of all unintentional injury deaths worldwide, is a formidable challenge that transcends geographical boundaries and affects individuals of all ages. The Automated Drowning Rescue Collar was conceived as a response to this crisis, offering a holistic solution that harnesses modern technology to mitigate risks and increase the efficiency of rescue operations. By leveraging GPS, accelerometers, gyroscopes, and advanced communication systems, this device not only enhances the chances of saving lives but also minimizes the risks faced by dedicated rescue professionals. The Automated Drowning Rescue Collar does not merely address a local or regional problem—it holds the promise of making a significant global impact. With its adaptability for use in aviation, marine, and military sectors, it transcends traditional boundaries and is poised to revolutionize drowning rescue operations worldwide. The potential for rapid deployment, whether by boats, cars, or drones, ensures that timely assistance reaches those in need, regardless of their location. By saving lives efficiently and safely, the Automated Drowning Rescue Collar aligns with global efforts to reduce drowning incidents and their devastating consequences.

One of the defining features of the Automated Drowning Rescue Collar is its commitment to sustainability and innovation. Powered by solar energy, it aligns with the goals of Oman's vision for technological progress and sustainable development. By utilizing renewable energy sources, the device not only reduces its environmental footprint but also sets a precedent for eco-friendly technologies in the field of drowning prevention and rescue.

The Automated Drowning Rescue Collar epitomizes the transformative power of technology and innovation in addressing global challenges. It's potential to save lives efficiently and safely, reduce drowning incidents, and support rapid deployment and supply transport positions it as a game-changer in the realm of drowning prevention and rescue. As we continue to refine and expand upon this life-saving technology, we remain committed to the noble cause of safeguarding lives and honouring the dedication of those who risk all to save others. The Automated Drowning Rescue Collar is not just a device; it is a symbol of hope, progress, and the enduring human spirit in the face of adversity. It has the potential to revolutionize drowning prevention and rescue efforts. Its technology-driven approach offers improved accuracy and safety compared to traditional methods, albeit with certain cost and maintenance considerations. Further research and collaborative efforts are essential to bring this life-saving innovation to communities around the world.

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