Abstract: Science and Engineering Fair of Houston

1198

Category:

Embedded Systems

HydroSentinel: A Distributed IoT Safety Net for Aging Public Water Systems Using Multi-Modal Sensors for Pipeline Leak, Contamination Detection, and Pump Health Monitoring

Ganeev Jaswal

Fort Bend ISD /Fort Settlement Middle School

HydroSentinel is a distributed IoT safety net created to protect aging public water systems. It uses a network of multi-modal acoustic, vibrational, and optical sensors. Millions of miles of buried pipelines in the US lose a huge amount of treated water each year due to hidden leaks. Contaminants can also enter the supply. Aging pumps and valves can fail unexpectedly, causing disruptions and expensive repairs. HydroSentinel tackles these issues by offering a low-cost, externally mounted, monitoring platform. It detects leaks, contamination events, and pump health issues in real time. Each HydroSentinel node includes an INMP441 digital acoustic microphone, an MPU-6050 vibration/IMU module, and a DFRobot turbidity sensor. These are managed by an ESP32-S3 microcontroller, which has data logging, edge processing, and long-range LoRa communication capabilities. The system uses local filtering, acoustic signature analysis, vibration pattern tracking, and turbidity-based optical scattering to find small leaks, discover potential contamination, and identify early signs of pump failure. Multiple nodes work together to create a distributed network, sending real-time data to a LoRa gateway. To test this , a PVC pipeline testbed was built. It included a controllable leak valve, a pump, a turbidity chamber, and specific sensor mounting points. Experiments revealed that HydroSentinel can detect leaks through sound before any visible water loss occurs. It can also observe spikes in turbidity that indicate contamination events and tell the difference between healthy and failing pump behavior through vibrational signatures. All events were logged locally, sent wirelessly, and displayed on a dashboard. HydroSentinel shows how a low-cost, multi-modal IoT sensing can improve the resilience and sustainability of municipal water systems. In neighborhoods or cities water utilities can detect problems earlier, maintain equipment more effectively, and significantly reduce loss.

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Abstract: Science and Engineering Fair of Houston

1199

Category:

Embedded Systems

Wearable Biometrics–Integrated Model for Early Detection of Nighttime Arrhythmia Risk

Aarvi Thota, Sanjana Ganglani

Fort Bend ISD /Sartartia Middle School

Nocturnal cardiac arrhythmias are irregular heart rhythms that occur during sleep and often go undetected, and heart disease remains the leading cause of death worldwide. Over 523 million people globally and more than 30 million adults in the United States live with heart disease. Because nighttime arrhythmias usually don't cause noticeable symptoms and routine daytime tests often miss them, many individuals remain undiagnosed, increasing the risk of stroke, heart failure, and sudden cardiac events. This creates a strong need for continuous and accessible nighttime heart monitoring. But current clinical monitoring tools are expensive, uncomfortable, and impractical for long-term daily use. To address this gap, we explored whether a low-cost, custom-built wearable device combined with supervised machine learning could classify elevated nocturnal arrhythmia risk using non-invasive biosignals. A wearable system was designed to continuously measure heart rate, heart rate variability, blood oxygen saturation, and motion during sleep. The electronics were housed in a 3D-printed, watch style device for comfortable overnight use. Data were divided into fixed time segments, and key features were extracted to capture meaningful physiological patterns. Therefore, a supervised machine learning model trained on expert-annotated arrhythmia data classified sleep segments as normal or elevated risk. The best-performing model achieved over 75% test accuracy and 100% recall, ensuring that all high-risk events were detected. These results demonstrate the feasibility of an affordable (<$35), non-invasive wearable system for early nighttime cardiac risk screening and support future research in accessible health monitoring technologies.

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Abstract: Science and Engineering Fair of Houston

1200

Arduino Password Unlock Door Security System

Alyan Hemdani, Arham Ahcom, Omar Hadi

Harmony Public Schools - South District/Harmony Science Academy - Katy

Category:

Embedded Systems

This project is about making a door lock that uses a password instead of a key. I built it with an Arduino Uno, a keypad, a servo motor, and an LCD screen. The lock only opens when the right password is typed. To test it, I compared my password lock to a regular key lock. I checked how fast each one opened, how often people made mistakes, and how safe each lock was. The Arduino lock worked well and only opened with the right code. People liked that they didn't need to carry a key, but I had to make changes to stop people from guessing the password too many times. By testing both locks, I learned that electronic locks can be faster and easier, but they need strong protection to be safe. This shows how coding and electronics can help make homes and schools more secure.

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Abstract: Science and Engineering Fair of Houston

1201

How Temperature Affects a Circuit's Resistance

James You

Conroe ISD /McCullough Junior High

Category:

Embedded Systems

In this experiment, I will investigate the effects of temperature on resistance in metals. When I began the experiment, I expected heat to increase resistance, because I knew that electronics have problems when overheating. For my experiment, I took a piece of aluminum foil and rolled it into a compact cylinder. After that, I got the materials needed to change the temperature of the tinfoil. I first measured the resistance of the foil at room temperature using a multimeter. Then, to heat it evenly, I boiled some water and poured it into a water bottle. After measuring the temperature, I put the foil in and let it heat evenly for a few minutes. I then took it out of the bottle and measured the resistance. I repeated this process for cold water and varying temperatures of warm and cool water. After writing down the results on a table, I found that the amount of resistance increases exponentially the higher the temperature is, and colder temperatures decrease it. The results for the most extreme temperatures and room temperature are 0.3, 0.4, and 0.9 for 32, 71, and 205 degrees Fahrenheit for cold, room temperature, and hot respectively. This shows how some electronics will fail when overheated and why engineers have to account for changes in resistance.

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Abstract: Science and Engineering Fair of Houston

1202

Environmental and Technical Influences on Wireless Signal Performance

Michael Sun

Conroe ISD /McCullough Junior High

Category:

Embedded Systems

This project investigated how the signal of wireless devices was affected by 3 factors: distance, material obstruction, and interference. An AM radio receiver and transmitter were placed 1m, 2m, 4m, and 8m apart, and the audio quality and the signal-to-noise ratio (SNR) were measured at each distance. Material attenuation was tested at a fixed distance of 2m using plastic, wood, and aluminum sheets placed between the receiver and the transmitter. Interference tests were examined by placing a Wi-Fi router in the center of the receiver and the transmitter. I tested the audio quality and SNR under three conditions: one with the Wi-Fi router off, one with it on but not actively running, and one with the router actively running. Results showed that SNR decreased as distance increased, demonstrating signal attenuation over space. The plastic sheet caused the least signal degradation, wood caused moderate attenuation, and aluminum significantly reduced SNR due to its conductive properties. During the interference test, the signal remained stable while the router was off, showed slight degradation when powered on, and experienced noticeable SNR reduction during active data transmission. This indicates how the audio quality of wireless signals can be easily attenuated through distance, specific materials blocking the signal path, and nearby radio-frequency interference.

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Abstract: Science and Engineering Fair of Houston

1203

A Light Bulb Full of Emotions

Nessa Cmerek

Clear Creek ISD /Westbrook Intermediate School

Category:

Embedded Systems

My project proposes a way to help people regulate their emotions in daily life using chromotherapy because studies show a positive correlation between specific light wavelengths (colors) and induced emotional states. This project is important because emotional regulation is an important aspect of well-being, and most people struggle with controlling their emotions. I used a Hubspace smart light bulb, and Machine Learning (ML) to classify audio input into the correct emotion. I selected what I found to be the 5 main emotions: happy, sad, angry, scared, and neutral. Then, using various sources, I matched each emotion to a certain color: happy to orange, sad to yellow, angry to blue, scared to purple, and neutral to white. After experimenting with different features, test sizes, and ML models, I improved the emotion classification accuracy from 60% to 73%. I integrated the model into my main code which records sound every 4 seconds, extracts features from it, fits it through the model to obtain an emotion label, and changes the light bulb color accordingly. The emotion detection accuracy could be improved with more trials and better hardware for faster and more efficient running speeds. In conclusion, my project can change color to enhance a user's mood based on vocal cues; therefore, it could make a huge impact on the future, giving a society where emotions are stabilized, discussions could happen, improvements could be made, and harmony is kept.

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Abstract: Science and Engineering Fair of Houston

1204

Flash Flood Alarms

Shlok Kalakkunnath

Conroe ISD /McCullough Junior High

Category:

Embedded Systems

I am making a flash flood sensor which is cost effective, low maintenance, easy to deploy, and within a 15 mile radius to the start of the flash flood. The flash flood sensor includes a water level monitor at 25%, 50%, 75%, and 100%. At 100%, there will be a buzzer, and that buzzer represents a civil defense siren. At 75%, notification will be sent.

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Abstract: Science and Engineering Fair of Houston

1205

Category:

Embedded Systems

Smart Cane: AI-Powered Obstacle Detection and Ultrasonic Identification for the Visually Impaired

Chetan Kodali

Conroe ISD /Knox Junior High

Traditional white canes often force visually impaired users to physically hit obstacles before detecting them. This causes painful bruises, cuts, or even serious head and facial injuries. Traditional white canes offer zero warning for mid-level objects and fail against glass doors and moving obstacles. They provide no clue about what the obstacle actually is, and leave people walking slowly and anxiously. To solve this problem, a Raspberry Pi-based smart cane was developed that combines a camera, YOLOv8n AI object-detection model, and an HC-SR04 ultrasonic sensor. The cane uses a simple but smart dual-confirmation logic: if only the ultrasonic sensor detects something within 50 cm, the buzzer makes one short beep as a general warning. Only when both the ultrasonic sensor confirms the object to be less than 50 cm and YOLOv8n (through the camera) confidently recognizes the object does the buzzer beep twice and the speaker clearly announce what it is(person, car, chair, etc.) using Festival text-to-speech. This real-time, reliable, low-cost system finally gives users both instant alerts about objects in front of them and actual knowledge of what's in front of them, making navigation safer, faster, and far more independent indoors and outdoors.

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