Demontrating Low Power Hibernation In Raspberry Pi Pico

IoT-Integrated Waste Management and Security System

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"Low power Hiberation" employs a Raspberry Pi Pico, motion sensor, sonar sensor, and a dedicated mobile app to enable two distinct modes: "Normal Open/Close" for remote waste disposal and "Detective Mode" for motion-triggered security in industrial waste scenarios. This integrated system ensures efficient waste management and heightened security, offering users seamless control and vigilance in waste disposal environments.

Keywords—Raspberry Pi Pico, Sensors, App, IoT

I. Introduction

Within the realm of power-efficient technology integration, a forward-thinking solution emerges, leveraging low-power hibernation with the Raspberry Pi Pico, a microcontroller known for its energy-efficient capabilities. This approach is particularly advantageous in environments with strict power constraints, such as industrial applications. The Raspberry Pi Pico takes center stage, serving as the pivotal component that orchestrates seamless communication between a camera and a display while prioritizing minimal power consumption.

The system's architecture revolves around maximizing energy efficiency through strategic control of power consumption. The Raspberry Pi Pico, functioning as the central neural hub, ensures the system operates in a low-power hibernation mode during idle periods. This energy-conserving strategy significantly extends the device's operational lifespan, making it well-suited for applications where power conservation is of utmost importance.

Equipped solely with a camera and a display, the system underscores the strategic use of controllers like the Raspberry Pi Pico to minimize power consumption during periods of inactivity. The emphasis on low-power usage, facilitated by this microcontroller, represents a notable shift in technology applications, contributing to a more sustainable and energy-conscious future.

II. Architecture

The chosen architecture for the system prioritizes seamless integration and efficient functionality. Central to this design is the Raspberry Pi Pico microcontroller, selected for its compact form factor, General Purpose Input/Output (GPIO) pins, and processing capabilities. Acting as the central control unit, the Raspberry Pi Pico effectively manages and coordinates interactions between various hardware components. Its GPIO pins facilitate communication with sensors, enabling real-time data acquisition and processing. The microcontroller's compatibility with diverse sensor types, ease of programming, and low power consumption make it an ideal choice for the core functionality of the system. Opting for the Raspberry Pi Pico is a deliberate decision based on its robustness, versatility, and capacity to serve as the neural hub orchestrating the system's operations.

III. Components

S.no	Components	Quantity
1	Raspberry Pi Pico	1
2	Resistors (4.7kΩ)	2
3	Display	1
4	Camera	1
5	LED	1

A. Raspberry Pi Pico

The Raspberry Pi Pico serves as the central processing unit and control hub of the Low Power Hibernation system. This microcontroller offers a compact form factor, GPIO (General Purpose Input/Output) pins for interfacing with various sensors and actuators, and efficient processing capabilities. Its role involves coordinating sensor data acquisition, processing information, and triggering appropriate actions based on predefined conditions.

B. Camera

The camera component in the Low Power Hibernation system serves as the visual input device. Designed for capturing images, the camera provides essential data for analysis within the system. Its primary function is to capture the numerical information from the environment, allowing the Raspberry Pi Pico to process and interpret the data. The camera's role is crucial in acquiring real-time information, enabling the system to make informed decisions based on the numerical data it captures.

C. Display

The display component plays a key role in presenting the system's output in a user-friendly manner. Integrated with the Low Power Hibernation system, the display provides a visual representation of the numerical predictions generated by the Raspberry Pi Pico. It acts as the interface through which users can easily interpret and understand the system's responses. The display receives output from the microcontroller, showcasing the predicted numbers based on the code fed into the Raspberry Pi Pico. This visual feedback enhances user interaction and understanding of the system's operations.

IV. METHODOLOGY

A. Requirement Analysis and Planning

THE METHODOLOGY FOR IMPLEMENTING THE LOW-POWER HIBERNATION SYSTEM USING THE RASPBERRY PI PICO BOARD BEGAN WITH A COMPREHENSIVE ANALYSIS OF REQUIREMENTS AND OBJECTIVES. THIS INVOLVED DEFINING FUNCTIONALITIES SUCH AS TEXT DETECTION, AUTOMATIC SLEEP MODE ACTIVATION, AND USER-CONFIGURABLE SLEEP DURATIONS TO ALIGN WITH THE PROJECT GOALS. PLANNING ENCOMPASSED OUTLINING THE HARDWARE COMPONENTS, INCLUDING THE RASPBERRY PI PICO, CAMERA MODULE, LCD DISPLAY, AND DEFINING SOFTWARE ARCHITECTURE.

B. Hardware Selection and Integration

THE SELECTION OF HARDWARE COMPONENTS WAS BASED ON COMPATIBILITY AND SYNERGY WITH THE LOW-POWER HIBERNATION SYSTEM. THE CHOSEN COMPONENTS INCLUDED THE RASPBERRY PI PICO, CAMERA MODULE, AND LCD DISPLAY. INTEGRATION INVOLVED CONNECTING THE CAMERA AND LCD DISPLAY TO THE RASPBERRY PI PICO USING APPROPRIATE INTERFACES, CONFIGURING GPIO PINS, AND ENSURING SEAMLESS COMMUNICATION BETWEEN THE HARDWARE ELEMENTS.

C. Software Development

THE SOFTWARE DEVELOPMENT PHASE INVOLVED PROGRAMMING THE RASPBERRY PI PICO MICROCONTROLLER FOR TEXT DETECTION USING THE CAMERA MODULE. ADDITIONALLY, A PROGRAM WAS DEVELOPED TO PUT THE DEVICE INTO LOW-POWER SLEEP MODE FOR A USER-DEFINED DURATION. NUMERICAL DATA FROM THE CAMERA, SUCH AS SLEEP DURATION, WAS DISPLAYED ON THE CONNECTED LCD. THE CUSTOM MOBILE APPLICATION DEVELOPMENT WAS EXCLUDED FROM THIS IMPLEMENTATION.

D. Sensor Calibration and Testing

ONCE THE HARDWARE AND SOFTWARE COMPONENTS WERE INTEGRATED, SENSOR CALIBRATION AND TESTING WERE IMPERATIVE. THIS PHASE INVOLVED FINE-TUNING CAMERA SETTINGS, ENSURING ACCURATE TEXT DETECTION, AND VERIFYING THE FUNCTIONALITY OF THE LOW-POWER SLEEP MODE. CALIBRATION AIMED TO OPTIMIZE SENSOR PERFORMANCE AND ACCURACY IN REAL-WORLD SCENARIOS.

E. Integration and System Testing

THE INTEGRATION PHASE INVOLVED COMBINING HARDWARE AND SOFTWARE COMPONENTS TO CREATE A COHESIVE LOW-POWER HIBERNATION SYSTEM. SYSTEM TESTING ENCOMPASSED VALIDATING THE ENTIRE SYSTEM, INCLUDING TEXT DETECTION, SLEEP MODE ACTIVATION, AND LCD DISPLAY FUNCTIONALITY. TESTING AIMED TO ENSURE SEAMLESS INTERACTIONS BETWEEN COMPONENTS AND ADHERENCE TO PREDEFINED FUNCTIONALITIES.

F. Iterative Refinement and Deployment

ITERATIVE REFINEMENT INVOLVED REFINING SYSTEM FUNCTIONALITIES BASED ON TESTING FEEDBACK. FINE-TUNING ALGORITHMS AND ADDRESSING ANY IDENTIFIED ISSUES WERE PART OF THIS PHASE. UPON SUCCESSFUL TESTING, THE LOW-POWER HIBERNATION SYSTEM WAS DEPLOYED FOR REAL-WORLD USE, READY TO OFFER AN EFFICIENT AND POWER-SAVING SOLUTION.

V. FUNCTIONALITY

A. Automatic Sleep Mode

THE SYSTEM IS EQUIPPED WITH A CAMERA MODULE FOR TEXT DETECTION. WHEN NO TEXT IS DETECTED FOR A USER-DEFINED DURATION, THE RASPBERRY PI PICO ACTIVATES A LOW-POWER SLEEP MODE. THE LCD DISPLAY SHOWS NUMERICAL DATA RELATED TO THE SLEEP DURATION.

VI. USAGE INSTRUCTIONS:

- TEXT DETECTION: THE SYSTEM USES THE CAMERA MODULE TO DETECT TEXT.
- AUTOMATIC SLEEP MODE: SET THE DURATION FOR AUTOMATIC SLEEP MODE ACTIVATION USING THE RASPBERRY PI PICO. THE LCD DISPLAYS NUMERICAL DATA RELATED TO SLEEP DURATION.

VII. CONCLUSION

THE IMPLEMENTED LOW-POWER HIBERNATION SYSTEM USING THE RASPBERRY PI PICO AND CAMERA MODULE OFFERS AN INNOVATIVE SOLUTION FOR EFFICIENT POWER MANAGEMENT. BY HARNESSING THE CAPABILITIES OF THE CAMERA FOR TEXT DETECTION AND THE LOW-POWER SLEEP MODE, THIS SYSTEM PROVIDES A USER-FRIENDLY AND ENERGY-EFFICIENT APPROACH. THE LCD DISPLAY ENHANCES USER INTERACTION BY PRESENTING NUMERICAL DATA RELATED TO THE SLEEP DURATION. THIS IMPLEMENTATION DEMONSTRATES THE POSSIBILITIES OF SMART, POWER-SAVING SOLUTIONS, PROMISING A MORE SUSTAINABLE FUTURE FOR EMBEDDED SYSTEMS.

VIII. FUTURE SCOPE

THE LOW-POWER HIBERNATION SYSTEM'S FUTURE APPLICATIONS EXTEND TO VARIOUS CONTEXTS. IN HOUSEHOLD SETTINGS, IT CAN SERVE AS AN ENERGY-SAVING SOLUTION FOR DEVICES THAT REQUIRE PERIODIC MONITORING. IN INDUSTRIAL ENVIRONMENTS, THE SYSTEM'S POWER-EFFICIENT DESIGN COULD BE BENEFICIAL FOR MANAGING AND CONSERVING RESOURCES IN AUTOMATED

PROCESSES. FURTHER ADAPTATIONS AND ENHANCEMENTS COULD BROADEN ITS UTILITY, ESTABLISHING IT AS A VERSATILE ASSET IN POWER MANAGEMENT ACROSS DIVERSE ENVIRONMENTS.

IV. REFERENCES

[1] *Raspberry Pi Pico Python Software*

- *App:* Thonny
- *Usage:* Enables programming and integration of the Raspberry Pi Pico microcontroller.