Tab 1

Snooze-Cruiser

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Proposal for ECE445, Senior Design

Feb.6 2026

1. Introduction

1.1 Problem

Sleep inertia is a well-documented physiological phenomenon characterized by impaired cognitive and motor performance immediately after awakening. During this transitional state, individuals often experience grogginess, reduced alertness, and diminished decision-making capacity. A common behavioral consequence of sleep inertia is the instinctive silencing of alarms without fully regaining wakefulness, resulting in oversleeping and missed obligations. In academic, professional, and healthcare settings, repeated failure to wake on time can negatively impact productivity, academic performance, workplace reliability, and overall well-being.

Traditional alarm clocks and smartphone alarms rely almost exclusively on auditory stimuli. However, auditory alarms can be cognitively processed and dismissed while the user remains partially asleep. Although some commercial alternatives attempt to address this issue—such as puzzle-based alarms requiring cognitive tasks or mobile alarms that move away from the bedside—these solutions often present limitations. Puzzle-based alarms may be disabled through habituation or secondary device use, while flying or highly mobile devices can pose safety risks in confined spaces such as dorm rooms or small bedrooms. Furthermore, many existing systems lack robust obstacle avoidance or spatial awareness, making them unsuitable for real-world indoor environments.

From a broader societal perspective, unreliable awakening systems affect public health and safety. Chronic sleep disruption and repeated oversleeping contribute to stress, absenteeism, and decreased performance. In safety-critical professions—such as healthcare, transportation, or industrial operations—delayed awakening may indirectly affect operational reliability. Economically, lateness and absenteeism reduce productivity and may carry cumulative institutional costs. Therefore, there exists a need for an alarm system that reliably induces full physical engagement while remaining safe, practical, and suitable for constrained indoor environments.

The fundamental limitation of current alarm systems is their failure to require meaningful physical activation to disable the alarm. An effective solution must compel the user to engage physically with the device in a manner that promotes full cognitive arousal.

1.2 Solution

We propose Snooze-Cruiser, a two-wheeled differential-drive robotic alarm system designed to physically move away from the user at the scheduled alarm time. Rather than relying solely on auditory stimulation, Snooze-Cruiser introduces a mobility-based engagement mechanism: when activated, the robot autonomously navigates the room, requiring the user to get out of bed and

physically retrieve the device in order to silence it. This enforced physical interaction increases heart rate, motor activity, and environmental awareness, thereby reducing the likelihood of returning to sleep.

The system is designed for safe and reliable operation in confined indoor environments. Snooze-Cruiser employs onboard sensors for obstacle detection and avoidance, ensuring it can navigate around furniture and walls without causing damage. Odometry-based localization enables the robot to remain within a predefined operational boundary, preventing unintended escape from the intended area. Unlike traditional alarms that are disabled by pressing a button, Snooze-Cruiser deactivates only when inertial sensing detects that the robot has been lifted or securely grasped. This interaction criterion ensures deliberate physical engagement rather than passive dismissal.

1.3 Visual Aid
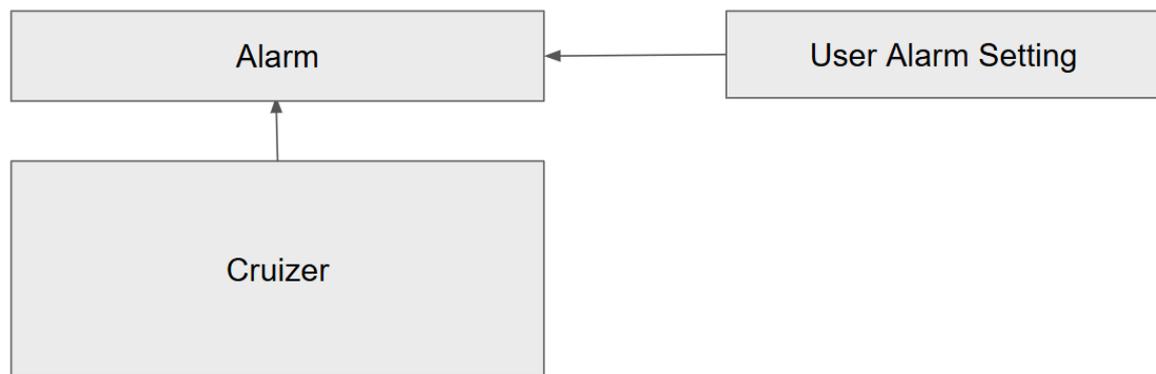
1.4 Success Criteria

Timed Activation:
 The alarm triggers within ±2 seconds of the programmed alarm time over at least 10 repeated trials.

Synchronized Operation:
 Robot motion and alarm audio begin within 100 milliseconds of each other upon alarm activation.

Autonomous Motion:
 The robot moves continuously without user intervention for at least 2 minutes while the alarm is active. No manual reset or external correction is required during operation.

Obstacle Avoidance:
 The robot detects and avoids static obstacles placed in its path. It must not collide with obstacles more than once per encounter, and no sustained contact with an obstacle may exceed 1 second.

Confined Operation:
 The robot remains within a predefined operating radius (e.g., 2 meters). If the boundary is exceeded, the robot autonomously redirects toward the defined region within 5 seconds.

Caught Detection:
 When lifted by a user, the robot reliably detects pickup using inertial sensor data. Motion and audio stop within 1 second of pickup detection. False stop detections occur in fewer than 1 out of 10 trials.

2. Design

2.1 Block Diagram
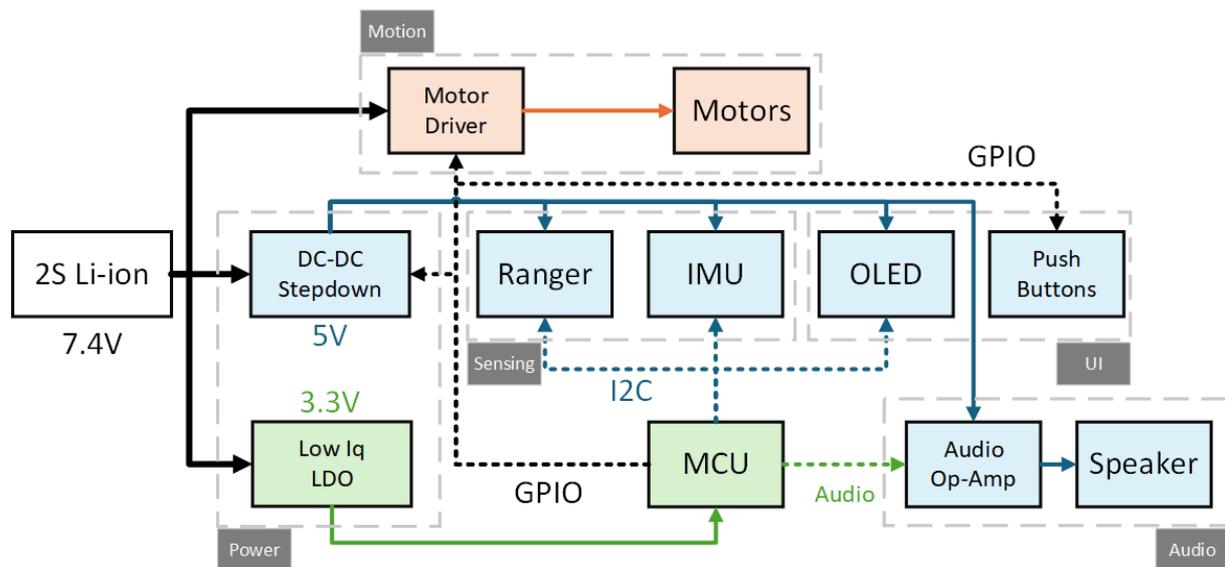
2.2 Subsystem Overview

The motion subsystem makes the alarm bot move and run away. The driver in the subsystem is integrated onto the mainboard and controlled via GPIO; the motors are soldered or connected via wiring posts.

The sensing subsystem perceives the environment to avoid collision, to estimate position and to detect whether the user has caught the alarm bot. The subsystem is installed on the mainboard as separate modules and communicates with the MCU on the I2C bus.

The UI subsystem provides the user with a simple display and several buttons to configure the alarm bot. The subsystem is installed on the mainboard as separate modules and communicates with the MCU on the I2C bus and by GPIO levels.

The audio subsystem plays a loud siren to wake the user. The audio op-amp is integrated on the mainboard and receives an analog audio signal from the MCU; the speaker is soldered or SMT or connected with wiring posts.

Power subsystem supplies other subsystems and the MCU with appropriate voltages. It is fully integrated onto the mainboard, and some voltages are gated with GPIO by the MCU to enable power saving.

2.3 Subsystem Requirements

The motion subsystem should enable the bot to move at no less than 3 m/s.

The sensing subsystem should detect obstacles within a 50 cm range in front of the bot, and robustly detect the user's catch.

The UI subsystem should display and respond to button presses, allowing the user to read the current time and configure the next alarm.

The audio subsystem should produce a siren at least 70 dB to effectively wake the user and annoy them.

The power subsystem should provide 3.3V to the MCU with low quiescent current and 5V to other subsystems with at least 1A of current.

2.4 Tolerance Analysis

There are several aspects of the project that exhibit risks to the success of the project. The main component will be the overall design of the PCB and will ensure that every subsystems connect well to the PCB.

As for the power subsystem, the MCU, IMU, ranger, and OLED all depend on the 3.3 V rail generated by the low-Iq LDO. Battery voltage (2S Li-ion) varies significantly with state of charge, and component tolerances in the LDO and passive components can cause the output voltage to drift.

Another risky part is that the sensing and UI subsystems rely on I²C communication. Pull-up resistors on SDA/SCL must be properly sized; resistor tolerances and bus capacitance can cause slow rise times or communication failure.

3. Ethics and Safety

3.1 Ethical Responsibilities

Snooze-Cruiser operates independently in close proximity to the user in confined indoor spaces. Therefore, safety and ethical considerations are fundamental engineering responsibilities. Engineers must adhere to the IEEE Code of Ethics by prioritizing the safety, health, and welfare of the public (IEEE I.1) and refraining from injuring people or property (IEEE II.9) [1]. Similarly, the ACM Code of Ethics requires computing professionals to avoid harm (ACM 1.2) and assess system risks (ACM 2.5) [2].

To comply with the IEEE and ACM Codes of Ethics, the following features are implemented:

- Speed and acceleration limits to avoid injuries due to collisions
- Obstacle avoidance via the use of ToF sensors
- Automatic deactivation of the motors in case of a "caught" condition
- No camera or microphone sensors to avoid privacy issues
- Documentation of the system's limitations to avoid misleading the public, such as the system's use only on flat surfaces and not on areas such as the stairs, in compliance with IEEE I.5 and ACM 1.3 [1], [2]

3.2 Development and Operational Safety

The following are the possible hazards during the development of the project: electrical short circuits, lithium battery hazards, and unintentional activation of the motor.

The operational misuse could include the modification of the firmware to enable faster speed or the use of the device near staircases. To ensure that there is no harm or injury resulting from the device's use, the speed limits of the device's firmware will be kept at levels that cannot be altered by the user, and the safe usage environment will be indicated in the device's manual.

3.3 Regulatory Considerations

The device's current design does not include the use of wireless transmission. Nevertheless, the device is considered a digital electronic device and must comply with the FCC's regulations on unintentional radiators under 47 CFR Part 15 [3]. If the device's future designs include the use of wireless transmission, the device will use pre-approved wireless modules and comply with the general provisions of Part 15 of the FCC's regulations, such as protection from interference and the capability to withstand interference.

3.4 Societal Impact

The device's use of physical activity to wake the person up has the positive societal goal of ensuring the person wakes up on time while ensuring the safety of the device's use in indoor areas. The device's design has considered the safety of the device's use by ensuring the device's operational parameters are within the safe limits, thereby ensuring the device's positive societal impact without the presence of safety and ethical issues, as ensured by the professional engineering codes of ethics [1], [2].

References

[1] IEEE, "IEEE Code of Ethics," revised Jun. 2020. [Online]. Available:
https://www.ieee.org/about/corporate/governance/p7-8.html

[2] Association for Computing Machinery, "ACM Code of Ethics and Professional Conduct,"
2018. [Online]. Available: https://www.acm.org/code-of-ethics

[3] Federal Communications Commission, "47 CFR Part 15 — Radio Frequency Devices,"
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