Intelligent Animal Shelter: Smart Kennel

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I. Problem

In our innovative project, we aim to address the well-being of animals through the development of a ”Smart kennel”. The core functionality of this system lies in the creation of a smart kennel with heating designed to automatically regulate temperature based on the presence of animals and environmental conditions, temperature to be exact. The project offers both autonomy and remote control features, ensuring the welfare of animals in various settings. Roughly speaking, this project aims to create a smart heating system.

II. Solution

Based on the problem we figured out four main objectives:

1) Kennel and Heating System: Develop a kennel integrated with a smart heating system to regulate the temperature inside.
2) Animal Presence Detection System: Implement a sophisticated system capable of accurately distinguishing when an animal is present inside the kennel.
3) Temperature Measuring and Regulation: Implement a temperature measuring system to continuously measure the temperature inside the kennel. Integrate a responsive regulation mechanism to maintain the temperature within the desired range.
4) Remote Control: Provide a user-friendly interface for remote control of the kennel. This includes the ability customize the parameters of the system and to receive real-time information such as the kennel’s occupancy.

Finally, we need to ensure automated heating activation by connecting all systems. This will produce a signal for heating activation only when necessary conditions are met. Specifically, when an animal is detected and the temperature falls below the desired threshold.

A. Temperature sensor

1) Choosing the right sensor:

When selecting a temperature sensor for our application, careful consideration was given to various factors to ensure precise and reliable temperature measurements inside the kennel. The MCP9808 sensor (Fig. 1) turned out as the optimal choice based on the following key criteria:

- In-House Temperature Processing: Our primary requirement was the ability to process temperature information directly within the kennel. The MCP9808 sensor provides a compact and efficient solution, enabling us to integrate it seamlessly into the confined space of the kennel.
- Extended Measuring Range: Recognizing the diverse environmental conditions that the kennel may encounter, we prioritized a temperature sensor with a broad measuring range. We defined a minimum working range from -30 to +50°C. The MCP9808 sensor boasts an impressive range from -40 to +125°C.
- High Accuracy: Precision in temperature measurement is important, and we defined an accuracy of ±1°C. to be acceptable in our case. This level of precision is crucial for maintaining a reliable and consistent temperature profile within the kennel. The MCP9808 sensor excels in this aspect, providing an accuracy of ±1°C in the worst case and in the best is accurate up to ±0.25°C.

Fig. 1. MCP9808 sensor

2) Setting up the hardware:

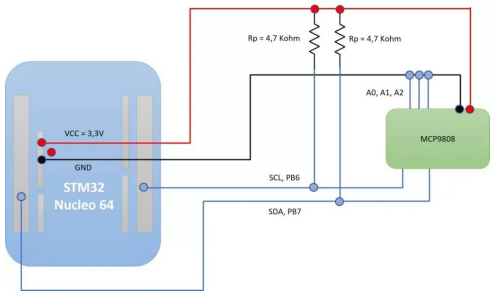

Fig. 2. Electrical schematic MCP9808

The sensor will be connected to an STM32F411 board. In the following pictures is possible to see the complete electrical schematic (Fig. 2).

B. Presence Detection System

1) Choosing the right system:

When exploring options for a presence detection system in our application, we thoroughly deliberated on different methods to guarantee accurate results. Initially contemplating the use of both weight checking and laser-based detection to identify animals within the kennel, we ultimately chose weight checking as the preferred method. This decision was motivated by the reliability concern associated with laser detection, which may not consistently identify animals. In contrast, weight checking using a load cell is a 100% reliable alternative, ensuring a foolproof presence detection system.

2) Selection of strain gauge HX711, combination of two strain gauges:

As mentioned earlier, we chose strain gauges to implement the idea of a moving floor in our kennel prototype. Also, we use exactly two strain gauges in order to increase the accuracy of the results. The strain gauge itself is connected to the microcontroller using a driver. Since we have two strain gauges, each will have its own driver, which will be recognized by the microcontroller. If we talk about the pinout of the driver, then from the main pins we have data transfer and clock. When the state of the clock changes from 0 to 1, data will be transmitted to the bluetooth module, which is described below.

C. Temperature regulation

To make the kennel even more intelligent, a strategic decision was taken to incorporate temperature regulation, achieved through manipulation of the power supplied to the electric rug positioned on the floor. To this end, a few options were considered, including PWM, transistors and TRIACs. Eventually, the choice was made in favour of a TRIAC. In particular, this choice is motivated by broader capabilities of TRIACs encompassing bidirectionality and the advantageous single-signal unlocking. The decision to opt for the TRIAC was further justified by the commercial availability of a device that

Fig. 3. Load Cell

allowed for more seamless integration of thermoregulation. In particular, the device that is now featured in the project (Fig. 4) was found a good fit due to its straightforward yet efficient operational mechanism.: it sends a signal out when the voltage drops to 0, thereby locking the TRIAC, and unlocks the TRIAC on receiving an external interrupt. Hence, PWM effect is achieved.

D. Main logic

Fig. 5 illustrates the interaction between the Presence Detection System and the Temperature System, demonstrating how they collaboratively send signals to activate the heating system. When an animal is detected, and the temperature falls below 15°C, the heating system activates. The system works dynamically to maintain a comfortable temperature, heating until it reaches 20°C. If the temperature drops below 15°C again, the heating process reinitiates, ensuring a continuous cycle. Also, if the animal leaves the kennel, the heating system turns off and remains inactive. This design conserves energy, ensuring that heating is triggered only when needed in the presence of animals.

E. Remote control

1) Choosing the communication medium:

The reasoning behind the choice of Bluetooth as the communication medium is quite logical. As the initial goal was to enable the end user to monitor the kennel's status and modify its operational parameters in close proximity, the preference leaned towards Bluetooth rather than WIFI. Moreover, the

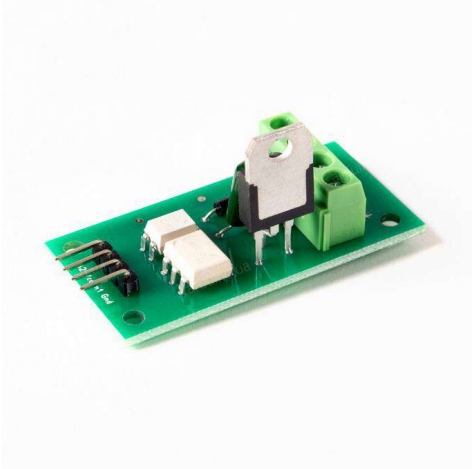

Fig. 4. TRIAC PCB

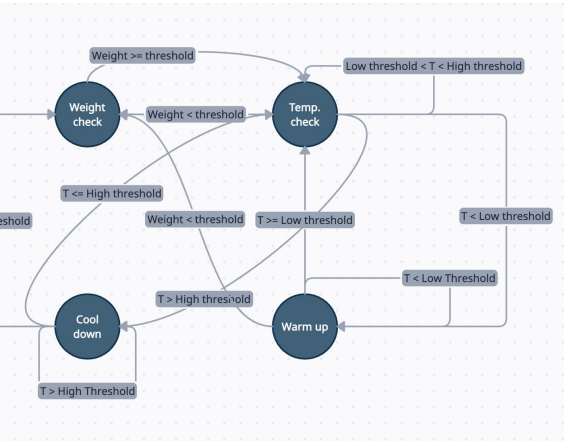

Fig. 5. FSM of logic

simplistic nature of data that would circulate between the user and the kennel also mandated the employment of Bluetooth.

2) Choosing the right Bluetooth module:

The underlying reasons of choosing HC-05 (Fig. 6) as a Bluetooth module include its compactness and a simple communication interface with the MCU. More specifically, UART is used for data exchange between HC-05 and MCU.

3) Interaction capabilities:

Presently, the user can establish a connection with the kennel using any Bluetooth-enabled device and engage in communication through a serial terminal application. The **GET** command allows to inspect the following status parameters:

- Lower temperature threshold (LWR)
- Upper temperature threshold (UPR)

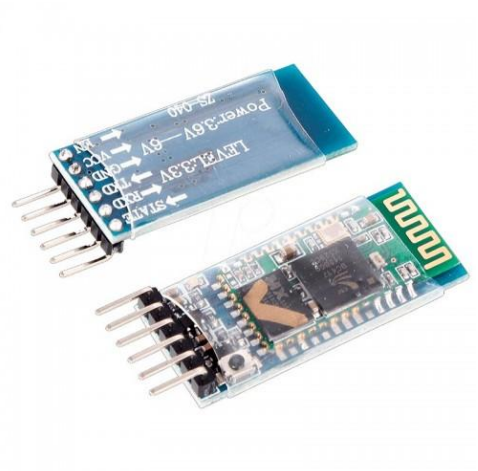

Fig. 6. HC-05 Bluetooth module

- Weight threshold for pet detection (WGT)
- Current measured temperature (CUR)
- Current set temperature (TMP)
- Current measured weight (LOD)
- Presence status (PRS)

The user can also customize aforementioned parameters by using commands of the following syntax: **SET+*Command Code*=(+/-)*2-digit value***

III. Results

The central idea behind the project was to merge several functionalities, including temperature and weight measurement, a kennel heating system, and remote control. The aim was to ensure that the kennel operates independently by utilizing these integrated features. The components work together seamlessly through our state machine, which includes temperature and weight measurement and heating control. This synchronized approach guarantees optimal conditions for the kennel's functionality. Additionally, the Bluetooth connection establishes seamless communication between the system and the user, allowing for real-time updates and remote control capabilities. Overall, the integration of these components results in an efficient and user-friendly system that promotes autonomous and controlled operation of the kennel.

Thank you for your time and consideration.