Self-Adjusting Jacket

ECE 445
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Project Proposal

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I. Introduction

1.1 Objectives

During the winter, the outdoor temperature varies a lot throughout the day. During autumn and spring, it may be cold like 20 Fahrenheit in the morning, but rise to 50s-60s during the day. This makes choosing a suitable jacket very hard. Wear a thinner jacket, you will be fine during the day but feel cold in the morning and at night. Wear a thicker jacket will make you sweat during the day but feel just right in the morning and at night. We also noticed that indoors are usually heated, so after you walk into buildings you would need to take off coat/jacket to avoid sweating. The goal of this project is to make a jacket that can sense the temperature outside and adjust the "thickness" of itself automatically.

1.2 Background

To adjust its thickness, we will make use of the insulating property of air. As opposed to a normal jacket, this jacket will have pockets which fill air inside (think of bubble wraps except the cells are all interconnected to each other through bridges). This is then connected to a valve and a air pump which can pump air in/let air out. When the outside temperature is cold, the pump will activate to fill the bubbles with more air to increase insulation, When the outside temperature gets warmer, a hole/fan will be used to let out air, thus making the jacket not as warm. There will also be a sensor that determines how "thick" the jacket is currently. In the case that the air pockets are not entirely air tight, and that the jacket becomes too "thin", the sensor can sense this and tell the pump to pump more air.

1.3 High Level Requirement lists

- Battery Life - In order to satisfy the usage, the battery can sustain and provide the electricity of the system for at least a day on a single charge.

- Temperature Range - The system will automatically adjust the thickness of the jacket (start to pump the air or leak the air) when a temperature change greater than 1 degrees Celsius occurs.

- Thermal Insulation - When the air pockets are filled with air to an appropriate level, the user will stay warm in an environment with a temperature of 0 degrees Celsius.

II. Design

2.1 Block Diagram
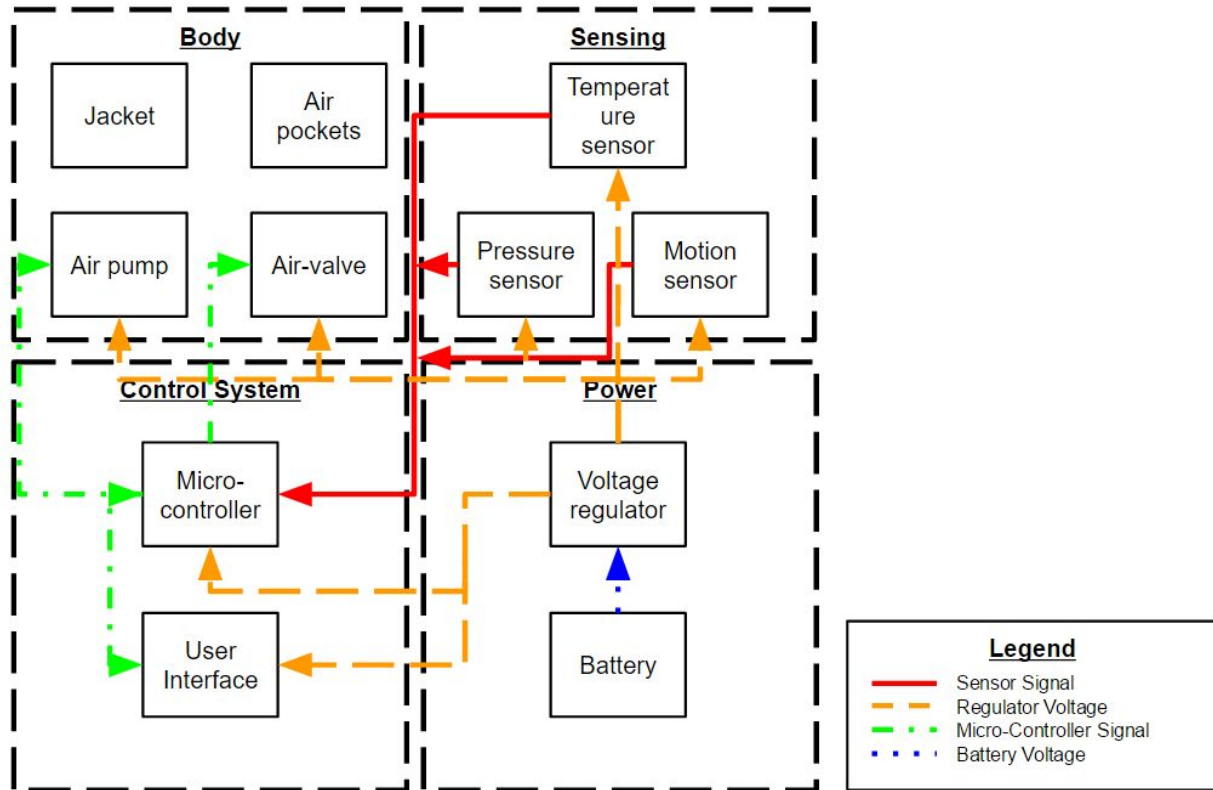
2.2 Physical Design

The Self-Adjusting Jacket, on the outside, will look like similar to a normal jacket. On the inside layer, in addition to the traditional thermal insulating material like down/cotton, there is an additional layer of inter-connected air pockets. Each air pocket is 10cm by 10cm, and they are connected to neighboring air pockets via bridges 2cm wide. At the bottom of the jacket, the air pockets are connected to the air valve, and then connected to the air pump. The air pump will be exposed to outside air via a small hole in the jacket. The electronic components of the jacket will be located near the air pump, with the temperature sensor exposed to outside air via the air pump hole.

2.3 functional overview

2.3.1 Body

The body module of the Self-Adjusting Jacket consists of the outer jacket, air pockets, an air valve, and an air pump. The air pockets, the air valve, and the air pump is made air-tight and serves as the adjustable thermal insulating layer. It's important that there's next to no air leaks so that cold air doesn't need to be pumped into the jacket constantly, which would jeopardize the thermal insulating property of the jacket.

2.3.2 Sensing

Temperature sensor:

The temperature sensor senses the current temperature outside and sends this information to the microcontroller of the jacket. The microcontroller then compares the temperature to the amount of currently in the jacket. It then opens the air valve or turns on the air pump to adjust the amount of air inside the air pockets, effectively adjusting the "thickness" of the jacket to an appropriate level.

Pressure sensor:

The pressure sensor measures the air pressure inside the air pockets and sends this information to the microcontroller. Using this information, the microcontroller determines the amount of air that's currently in the air pockets. This information is compared to the temperature outside to help the microcontroller determine if the air pockets are inflated to an appropriate level.

Motion sensor:

The motion sensor measures whether the jacket is currently being worn. It sends this information to the microcontroller.

2.3.3 Control system

Microcontroller:

The microcontroller receives data from the sensors, interprets the user setting from the user interface, and controls the air pump and the air-valve. The microcontroller takes in the outside temperature data from the temperature sensor and determines the appropriate air pressure that should be in the air pockets for the optimal "thickness" of the jacket according to the user setting. It will then compare the optimal air pressure to the current air pressure in the air pockets according to the pressure sensor. If the difference between the two is high enough, It will either open the air valve to release air or pump more air into the air pockets to adjust thickness of the jacket. The

microcontroller also takes in data from the motion sensor. When the motion sensor senses no movement for a certain amount of time (the jacket is not being worn), and the temperature sensor senses the outside temperature is above 18 degrees Celsius (room temperature), the microcontroller determines that the user has entered indoors and taken off the jacket, and enters indoors mode. In this mode, the microcontroller pumps the jacket up to full capacity using warm air indoors and maintains it that way. Once the user puts on the jacket again, and goes outside (signified by temperature drop from the temperature sensor and movement from the motion sensor), the microcontroller returns to the default mode and adjusts the thickness of the by opening the air valve and letting air out.

User Interface:

The user interface is a knob that lets the user set how warm he/she wants the jacket to be. For example, someone that get's hot relatively easily can set it the knob to low temperature, compared to someone that get's cold easily and sets the knob to high temperature. In this case, the jacket with the low temperature setting will be thinner than the jacket with high temperature setting for any arbitrary outside temperature.

2.3.4 Power

Battery:

The battery powers the electrical systems of the Self-Adjusting Jacket. The battery is rechargeable and provides a 12V voltage. It feeds directly into the voltage regulator.

Voltage regulator:

The voltage regulator takes a voltage input from the battery and outputs a constant 12V voltage for the control systems, the body, as well as the sensors. This ensures the correct operation of the systems.

2.4 Block requirements

2.4.1 Body

● The inner air pockets must be airtight enough that when it's pumped up with an air pressure of 1Atm inside, the air pressure will stay within 0.1Atm after an hour. And it will be able to stand a maximum air pressure of 2Atm.
● The air pump can pump air into the air pockets with an air pressure of more than 1.5Atm.
● The air valve can open and close within 5s 99% of the time.

2.4.2 Sensing

- The temperature sensor can sense the correct temperature within 0.2 degrees Celsius 99% of the time
- The pressure sensor can sense the correct air pressure to within 0.05Atm 99% of the time.
- The motion sensor can correctly detect motion 99% of the time.

2.4.3 Control System
- Microcontroller will receive and interpret signals from the sensors correctly 99% of the time.
- Microcontroller will send appropriate signals based on sensor input and User Interface input to the air pump and the air-valve 99% of the time.

2.4.4 Power
- The battery will supply a voltage of 12(+/-2)V and power all the functions of the jacket for 12 hours.
- The voltage regulator will output a constant voltage of 12(+/-0.1)V

2.5 Risk analysis

The block that posts the greatest risk is the power supply. Since we are attaching batteries and voltage regulator on the jacket, if the batteries or the regulator overheat, it may cause the jacket to burn and lead to fire.

III. Ethics and safety

I think this project is relatively ethic among other projects in ECE 445. Because this is a simple design and upgrade of cloth, it is hard to use as a threat. However, on the safety side; for example, wearing this jacket while aboarding an airplane might cause some security and safety concerns since the design contains metals and batteries. And while we design and build this project, we need to make sure that the process of air pump is safe and accurate. If overpumped, the jacket might explode and cause damage.