Canine Palpation Trainer

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Project Summary:
Palpation is an important medical procedure which allows both doctors and veterinarians to quickly assess the health of major organs. By using their hands on a patient, health care professionals can gather data that visual inspection alone cannot provide. With palpation, doctors can learn the skin’s temperature, the skin’s moisture, the health of organs, and internal swelling.

The project began with a focus on canine palpation. To correctly perform a palpation procedure on a dog, one must use three fingers on each hand. A figure of the proper procedure can be seen below:

Unfortunately, training a large number of students on how to perform a palpation procedure can be difficult. A few years ago, palpation would be taught on a live animal; an entire vet class would palpate the dog’s abdominal cavity. Over time, the dog would become less cooperative and could eventually lead to the dog biting. Furthermore, by the time the entire class had practiced palpating, the dog’s stomach would be tender, if not bruised. To solve this issue, the vet school created a silicone model.

The goal of Canine Palpation Project is to create a silicone dog model which has embedded sensors for accurate and real time feedback for veterinary students.

Importance:
Palpation is important because it teaches veterinary students to perform an inexpensive diagnostic procedure. Palpation can prevent the need for expensive x-rays by determining if there are masses on the organs. The canine palpation trainer is crucial for teaching students how to performance palpation properly. Specifically, teach student the correct location of the organs including, liver, stomach, spleen, intestines, kidney and bladder.
Canine Palpation Trainer is a second semester project. As such, we have already started the testing process. We approached the project with a rapid prototyping mindset. By creating multiple models, we were able to learn the potential problematic areas early on and plan for the issues. This allowed us to have proof of concept and partially finished models by the end of the first semester. The second semester has been mostly about assembly of the hardware, computer software, and microcontroller firmware. Each of the three subsystems have been modeled and tested, but have not been tested in unison. Figure 1 below is our second semester plan. While only 4 weeks are planned for actual testing, the test process has been ongoing and thorough.

We settled our design requirements during the first weeks of the project. It allowed us to plan for certain design requirements immediately and put our own technical constraints where we felt necessary. For instance, we decided that the model should be powered from a wall outlet. The veterinary school didn’t have the expertise to tell us what they needed in that case.

To determine the design requirements we met with our customer (the veterinary school) and talked with the dean and the students about what exactly they need, what they want, and what they wish they could have. Here are the results:

**Needs**
- Feedback
  - Was the palpation performed in the correct area?
  - Was the palpation too hard or too soft?
Can be calibrated by an expert after each power cycle for accuracy.
- Last for 2+ years
- Easy to use, setup, put away, and maintain
- Easy to mass produce

**Wants**
- Visual feedback
  - highlighted pressure on a picture of the canine model
- Always calibrated.
- Last for 5+ years

**Wishes**
- Feedback
  - color highlighting on a 3D canine model
  - audio feedback eg dog barking if pressure is too high
- Ability to inflate organs to simulate organ disease
- Apply to other animals including humans
- Inexpensive

Furthermore, we tried to understand the operating requirements. The veterinary school simply told us that the operating requirements were just that it needs “to work.” By having unrestricted operating requirements, we had high flexibility and were able to determine our own requirements.

**Operating Requirements**
- 0 to 60 degrees Celsius
  - planning for storage of units
- Update each pressure value in under 1 second for accurate, live feedback.
- Maximum applied force 100N
- Input 5 volts voltage

By the end of the twelfth week, we will have a completed model. This means that we will have embedded sensors in all of the organs and have all the wires leading back to a control box. The control box will contain the microcontroller, power switch, and resistors. The microcontroller will be connected to the point between the pressure-sensitive resistors and the constant resistors. The microcontroller will multiplex the incoming voltages, perform and analog to digital conversion, and record the data. Depending on time constraints, the
results will either be sent to a computer via bluetooth or displayed on an LCD connected to the microcontroller.

Each piece of the system has been thoroughly tested individually. For instance, the pressure sensors were put in brutal test environments (like the freezer) and performed accurately. The microcontroller code has been run continuously performing A/D conversions for weeks at a time to ensure there are no memory leaks or errors. The bluetooth module works independently of the microcontroller and has been tested by extended tests of continuous bit streams using an Arduino microcontroller. However, it doesn’t work when connected to the PSoC microcontroller. This is most likely a coding error and will be fixed and tested. Lastly, a rudimentary GUI has been created which has 12 text boxes to output pressure data on the computer screen. This model has been tested with extended use and has performed well.

The major issues will arise when each of the major components are put together. Here are the concerns and areas we have been checking to avoid stop-ship problems:

**Hardware to Microcontroller**
- Signal integrity - the voltage will travel ~6 inches before the A/D converter
  - Where do we filter signal?
  - Do we need to filter?
- Wiring problems
  - Goal is to make it easy for a non expert to reassemble
    - Modular design where each organ can be removed and replaced easily. This adds design issues with connectors
    - RJ45 connections for each organ

**Microcontroller to Bluetooth**
- Is the correct data being transmitted with low error rates?
- Can the bluetooth module transmit properly from inside the model?
  - What position gives us the best signal
- What should the packets look like and how big should they be?
  - Could cause timing issues by not being able to transmit enough data fast enough

**Bluetooth to Computer**
- Does the data from microcontroller match the data on the computer side
- Is the connection stable?
  - packet loss?
- connection issues
- How do we handle a reconnection after disconnection?

- Baud rates
  - Is the data transmission rate fast enough to update all 12 sensors every one second

Sensors will be placed on the surface of those organs by painting a thin layer of additional material on top of it. We will have to make sure that the sensor will be mounted stable and fixed. At the same time, the connection between sensors and resistors will be solder joint, it could possible be a weak point of all the connections. Therefore, a solid solder joint is required and should be tested.

To perform tests on the complete model, we will treat it exactly like it will be treated in the field. This means that we will perform stress tests. This could mean everything from dropping it to letting a child palpate on it. The model is required to last for 2 years of palpation which means that it must survive around 600 palpation procedures. To test this, we will take the model out, perform around 30 palpations turn the power off, put the model away, and repeat. Taking the model out involves bumping it around a bit. We need to be absolutely sure that the current design isn’t prone to failure when put under normal stresses like that. The palpation can range anywhere from far too soft to hard hard so we will need to ensure that the sensors can withstand the force of an “enthusiastic” palpation. We will also need to be sure that when the model loses power it correctly saves its progress and disconnects from the paired bluetooth device. All of these tests can be performed by simulating use.

From the palpations, we will be getting 12 different 8-bit numbers. The numbers will range between 0 for no palpation to 255 for extreme palpation. The model can be tuned for sensitivity easily by replacing the resistor which is in series with the sensor. We have chosen the resistor so that both 0 and 255 are achievable values and they are within the desired pressure ranges. The ideal pressure ranges are obtained from having an expert palpate the canine model each power cycle (which might be saved in the future). The current model will display the organ that is being palpated on the LCD screen while performance the palpation. Therefore, we can have the expert palpate certain organ and exam if the LCD displays the correct result. Future iterations will have bluetooth transmit this data to the computer and have a 3D model of a canine highlight the area that is being palpated along with colors to indicate the pressure (eg red is too hard, green is perfect, purple is too soft). The purpose of the procedure is to guarantee the GUI will operates correctly.

We will only need an oscilloscope for this project. We will use it to verify that the output from the bluetooth module matches the data received on the computer side.