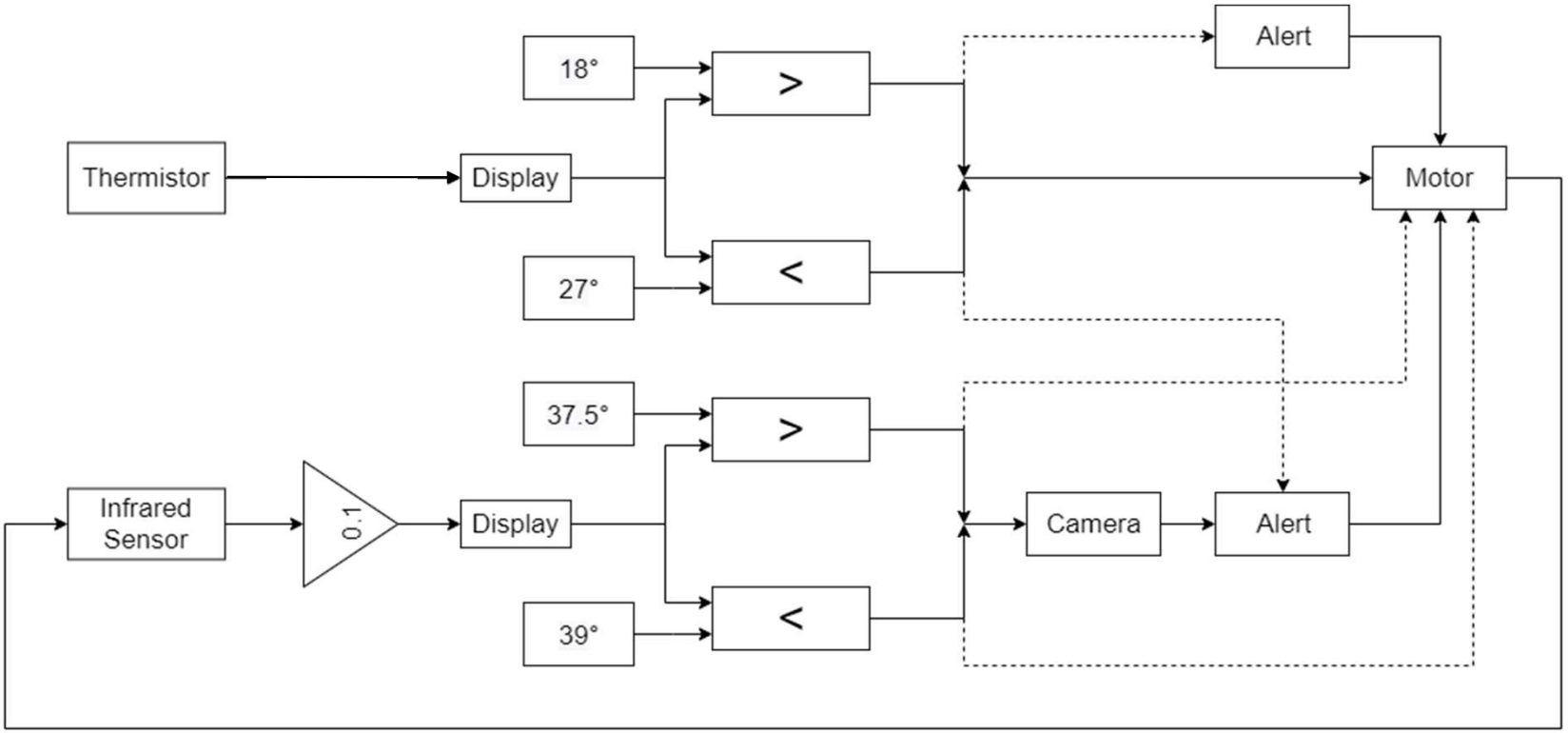
Infant Temperature Monitor

By Amr Abdelhamid and Ethan Webster

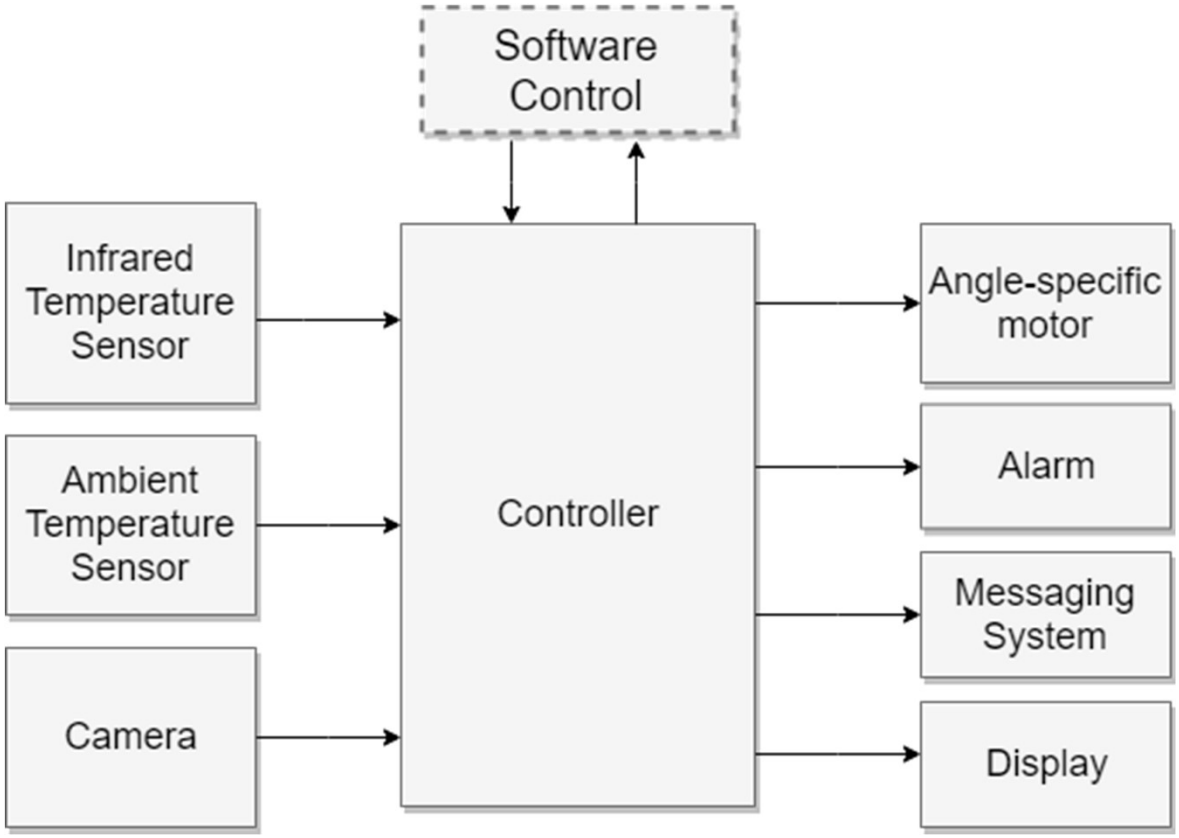
Problem Statement

- Proof of concept: analyzing the feasibility of infrared temperature sensor for measuring body heat
- Temperature measurement without direct contact
- Enhanced monitoring system for infants
- Incorporation of multiple sensors and actuators to perform smart monitoring

Model

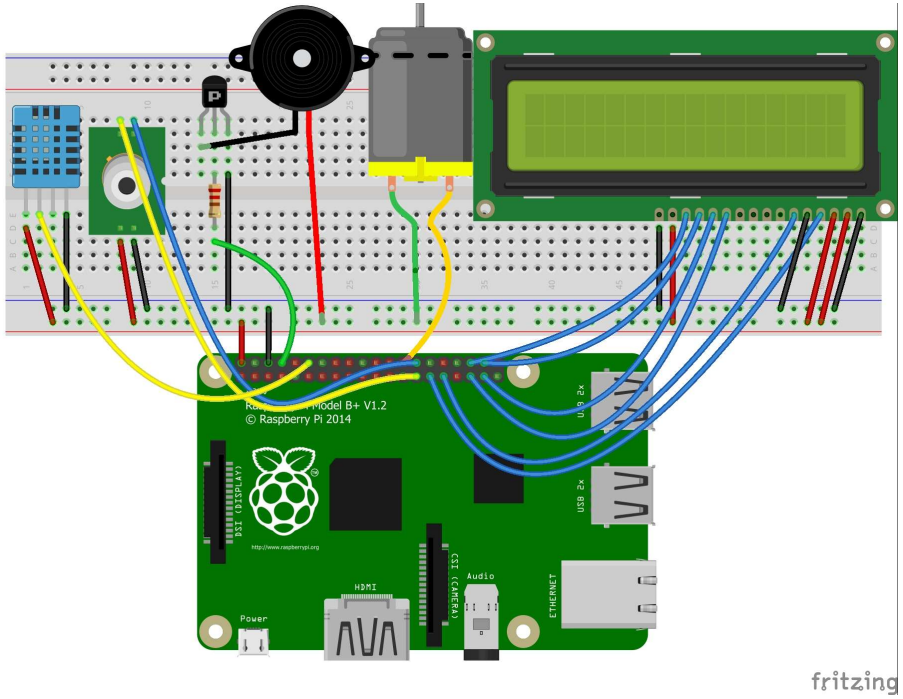

Alert
18°
>
Thermistor
Display
Motor
27°
<
37.5°
>
Infrared Sensor
0.1
Display
Camera
Alert
39°
<

Conceptual Design

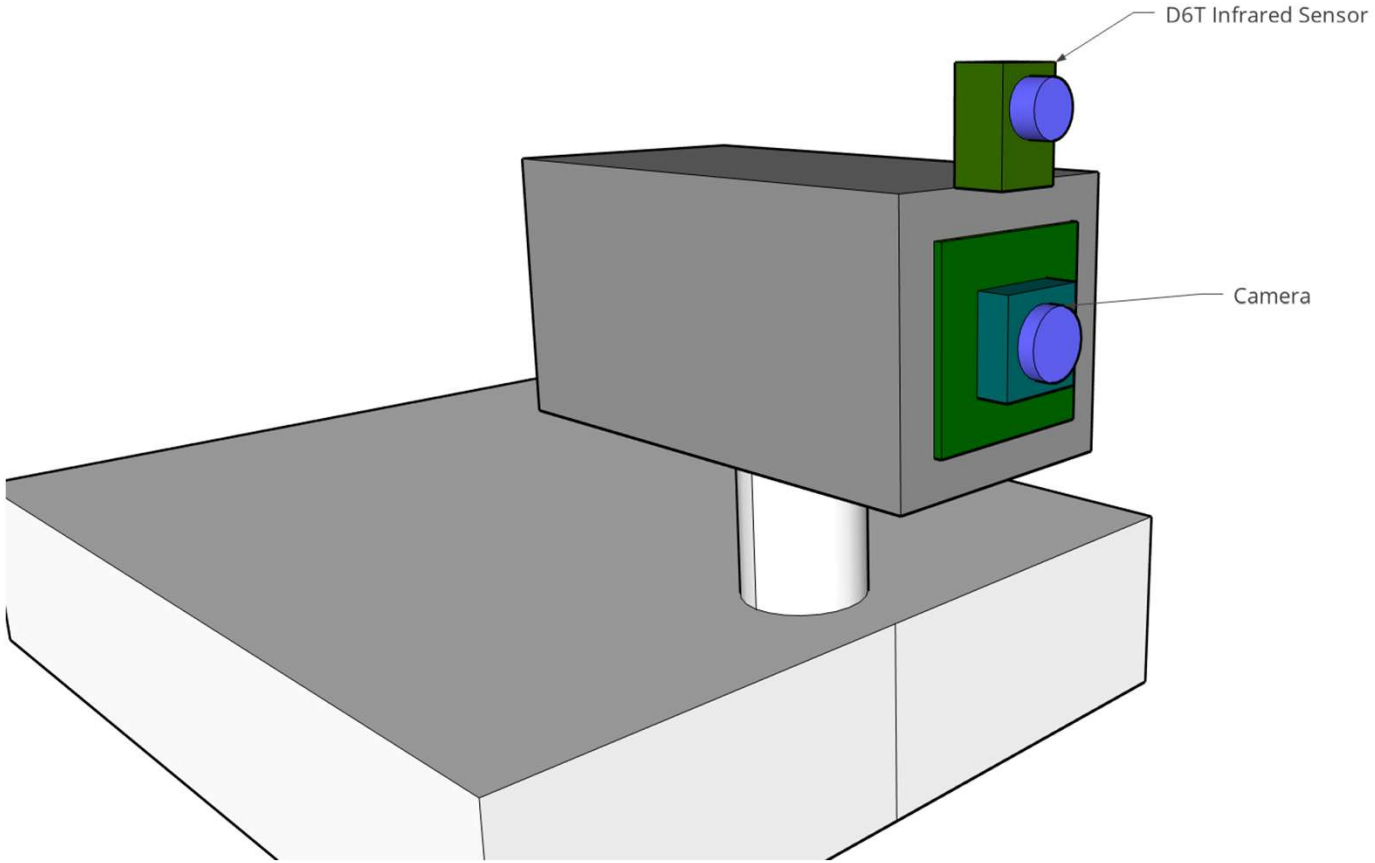


Schematic

- The design consists of:
  - RPi microcontroller
  - D6T infrared sensor
  - DHT11 humidity and temperature sensor
  - Camera
  - Stepper motor



Prototype: Main Components



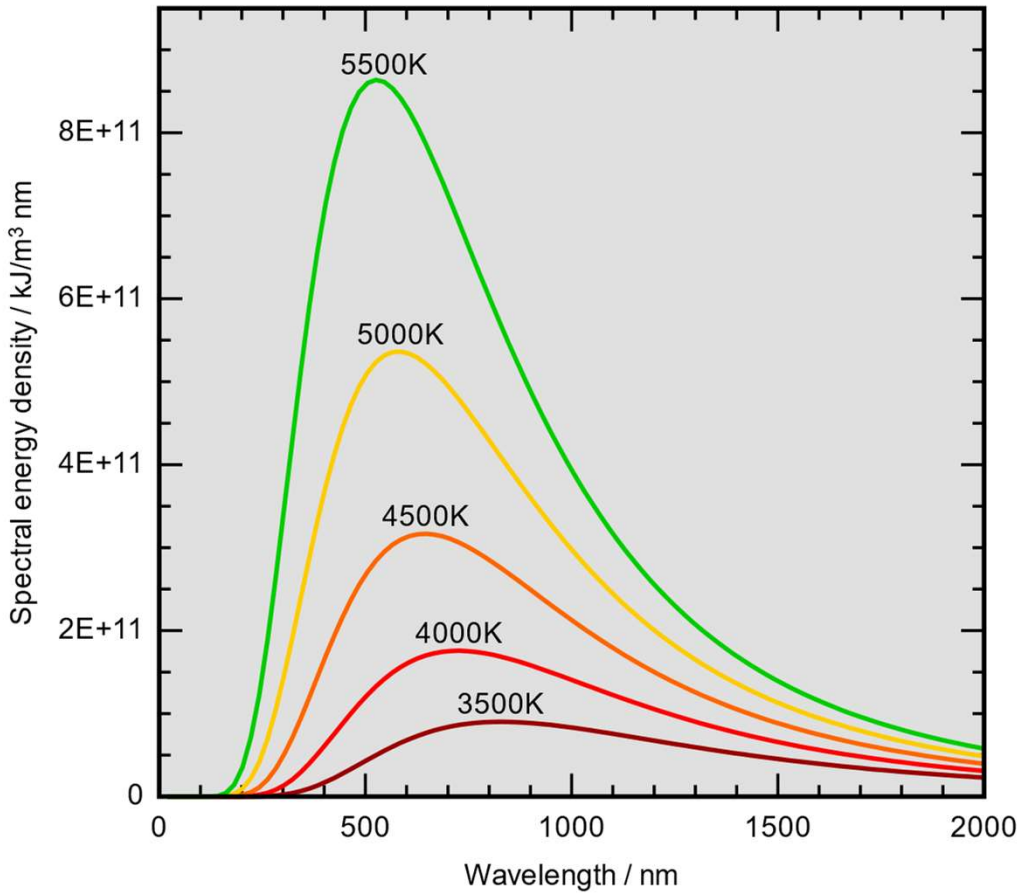
Infrared Sensor: Principles

- **Planck's Radiation Law**: Any object whose temperature is not equal to absolute zero emits radiation.
- **Stefan Boltzmann Law**: The total energy emitted at all wavelengths by a black body is related to the absolute temperature.
- **Wien's Displacement Law:** Objects of different temperatures emit spectra that peak at different wavelengths that is inversely proportional to temperature.

Wien's Displacement Law

$$\lambda_{max} = \frac{b}{T}$$

where b is Wien's displacement constant

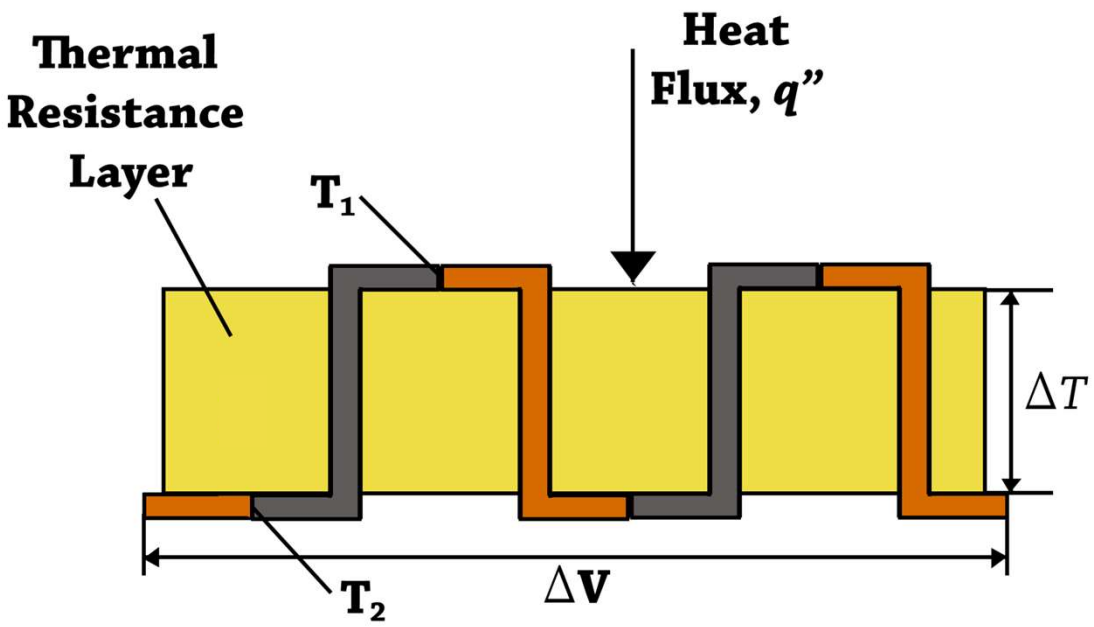


Infrared Sensor: Principles

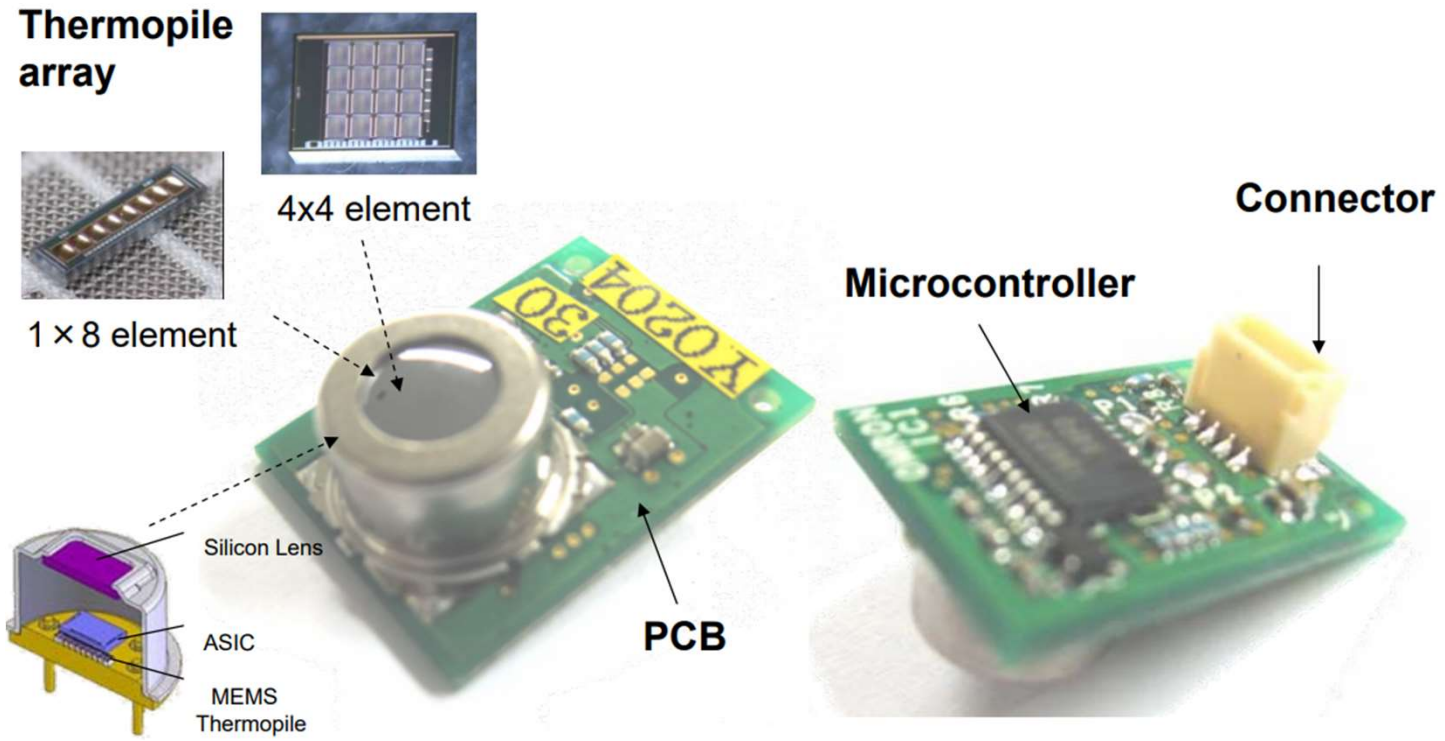
Thermopile: a series of thermocouples

$$\Delta V \propto \Delta T$$

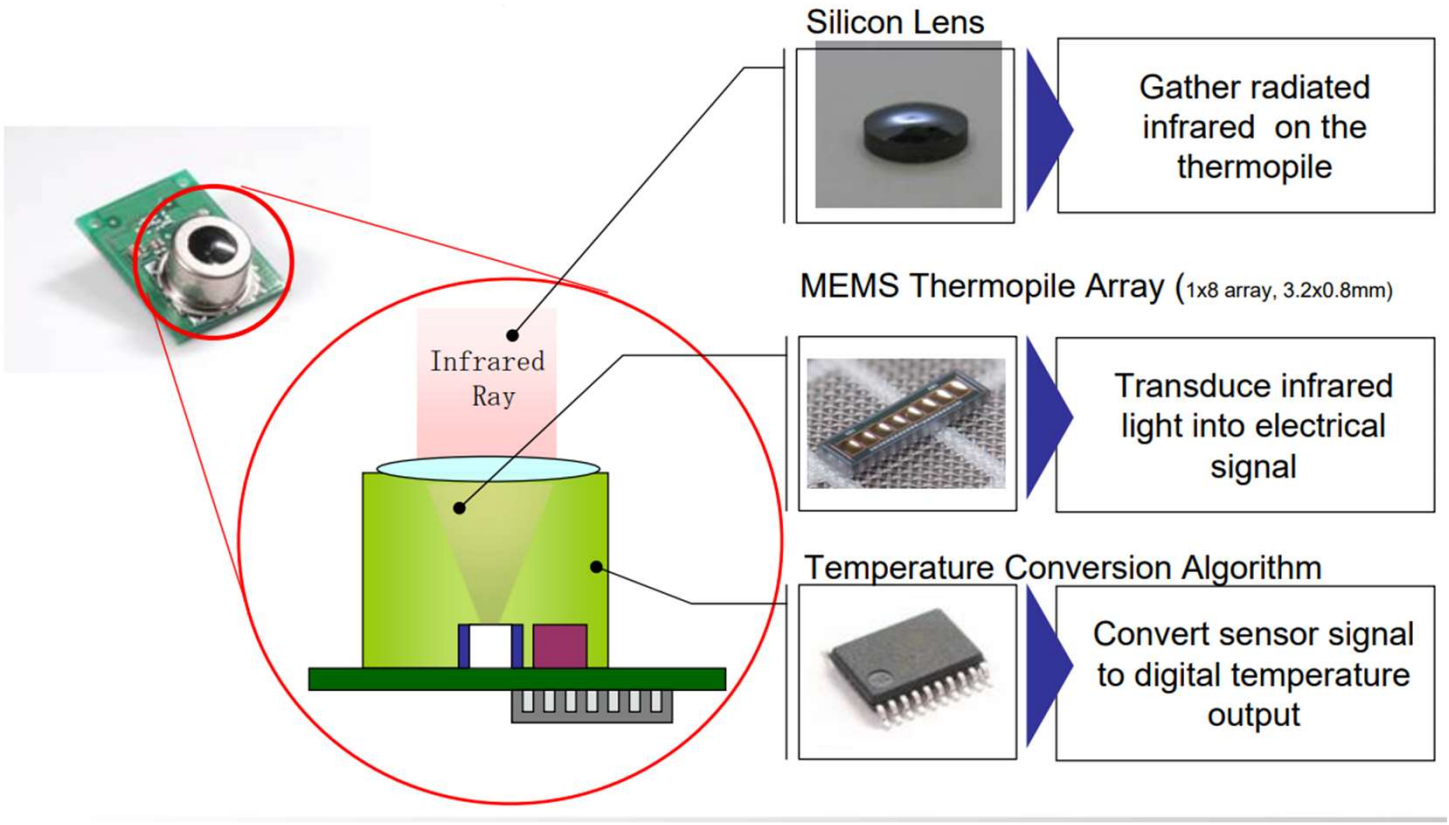
$$\Delta V \propto q"$$



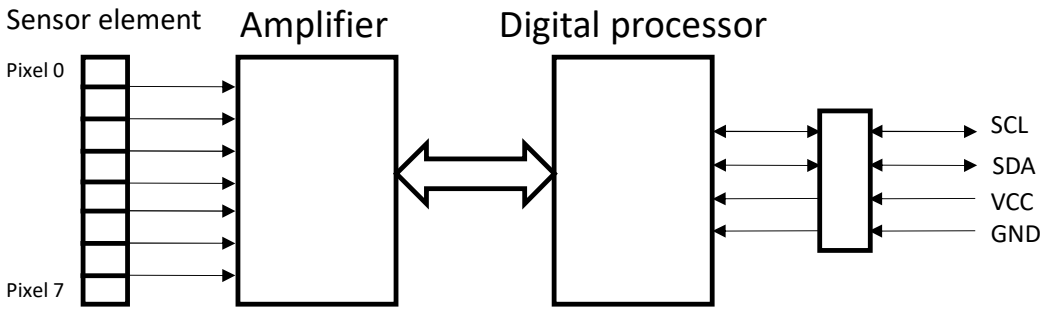
D6T Sensor


Thermopile array
4x4 element
1 × 8 element
Silicon Lens
ASIC
MEMS Thermopile
PCB
Microcontroller
Connector

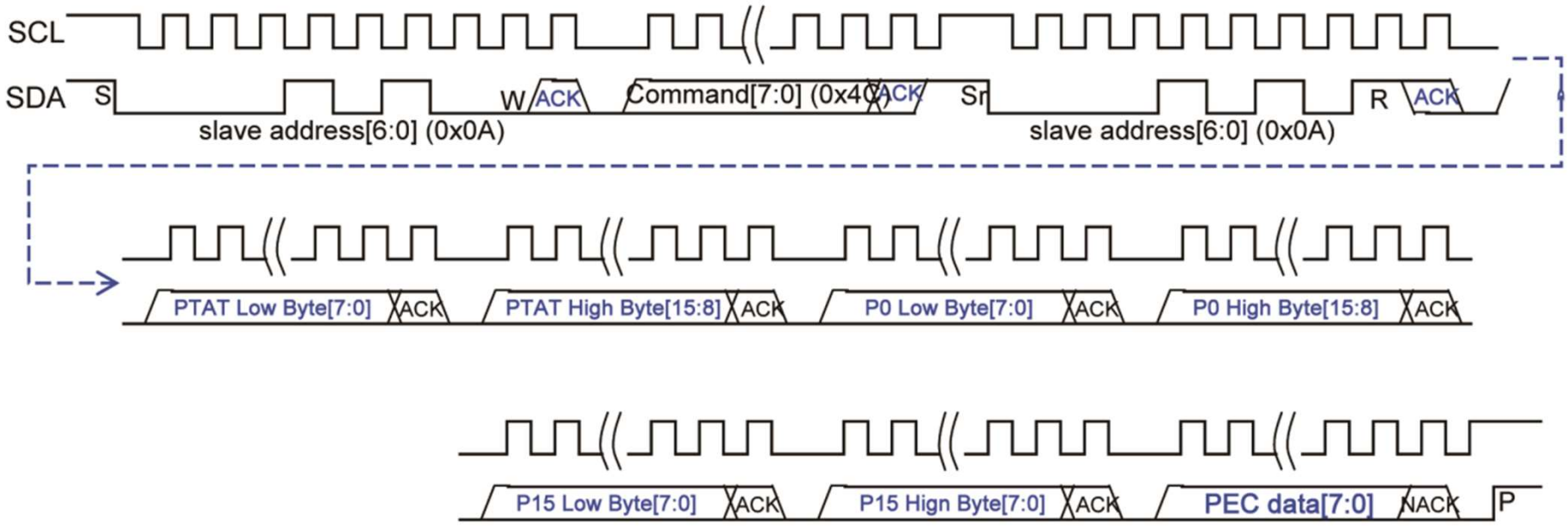
D6T: Operation Principle



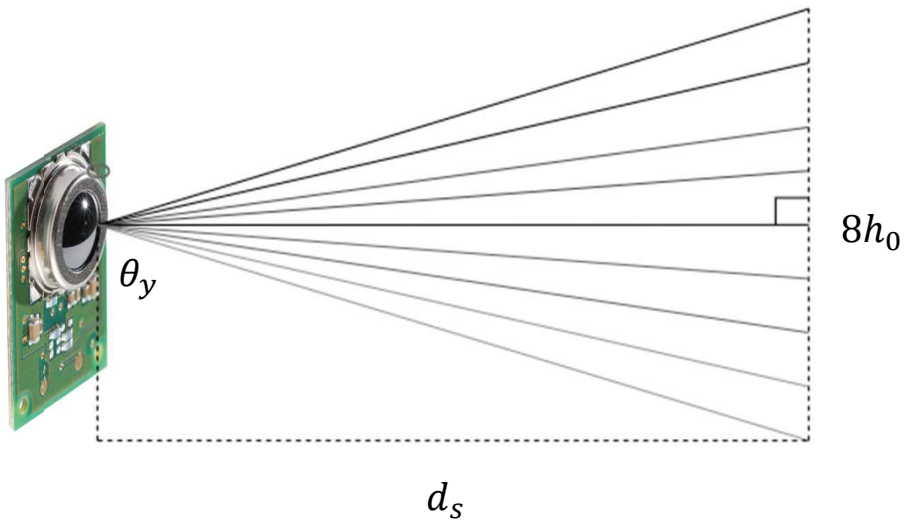
D6T: Operation Principle



D6T: Operation Principle



Relating Distance with FOV

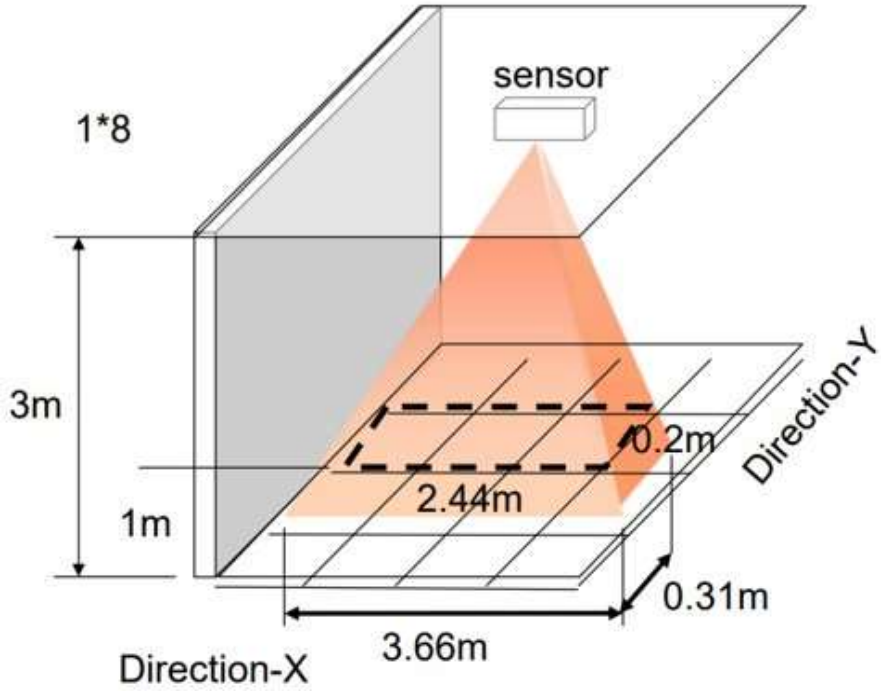


The maximum distance to place the sensor from the object (or human) based on the object height is:

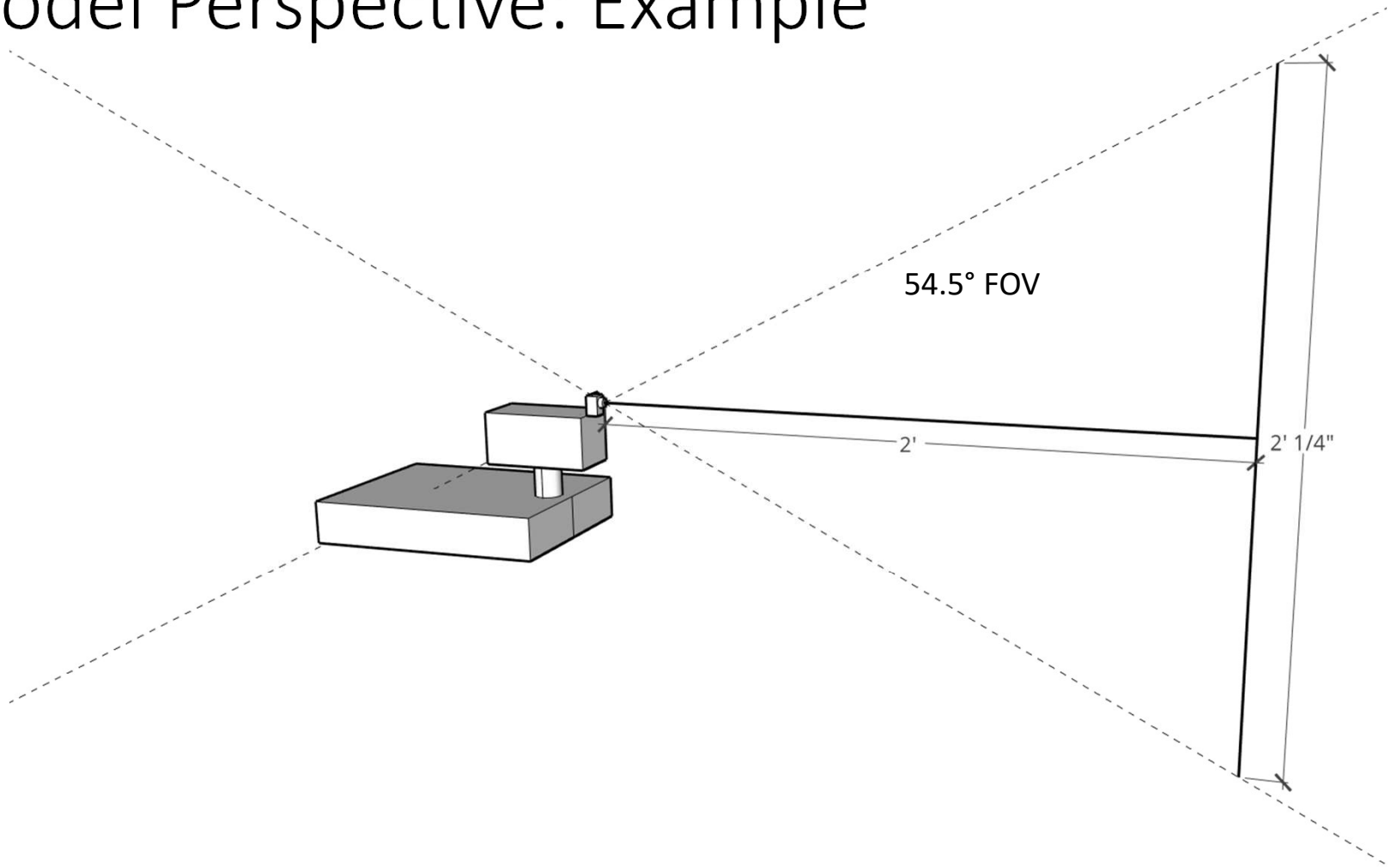
$$d_s = \frac{8 * h_0}{2 * \tan\left(\frac{\theta_y}{2}\right)}$$

where h_0 is the height of a single temperature pixel and θ_y is the FOV angle in the y direction.

Model Perspective: Example

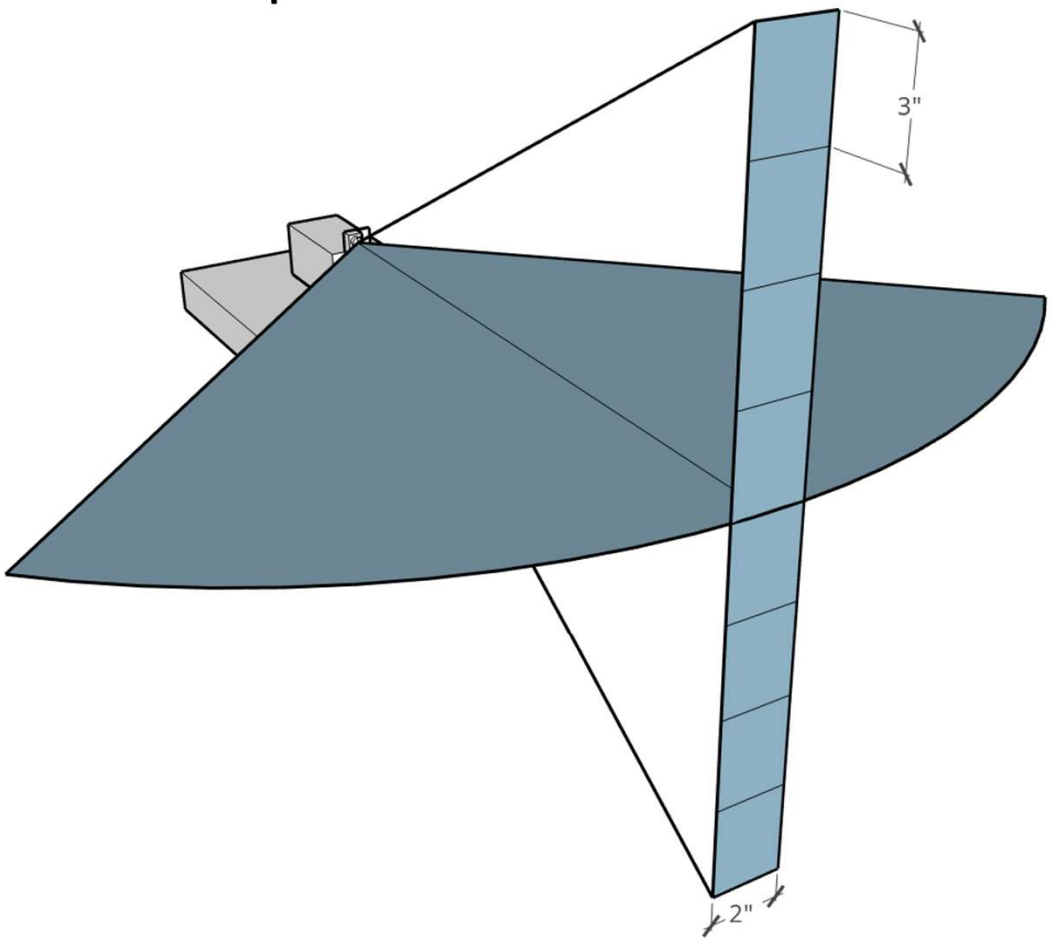


Model Perspective: Example

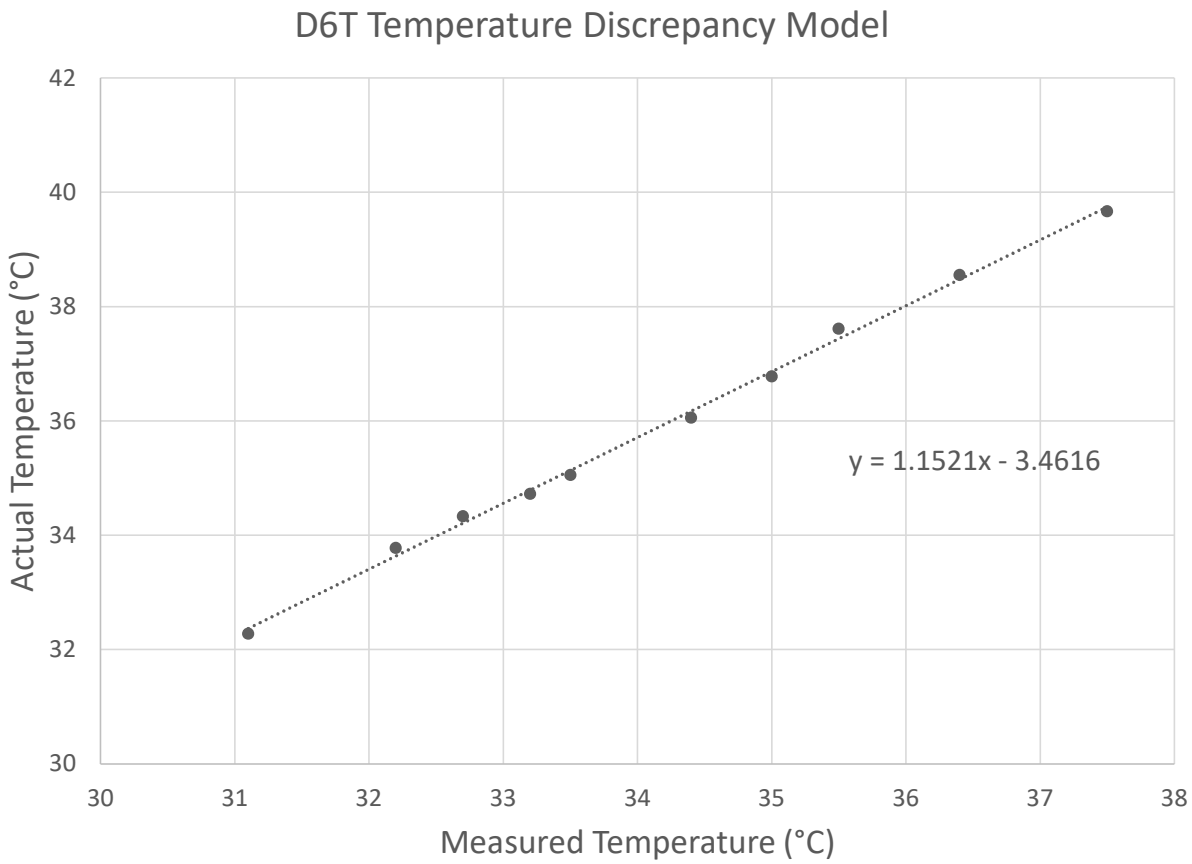


Model Perspective: Example

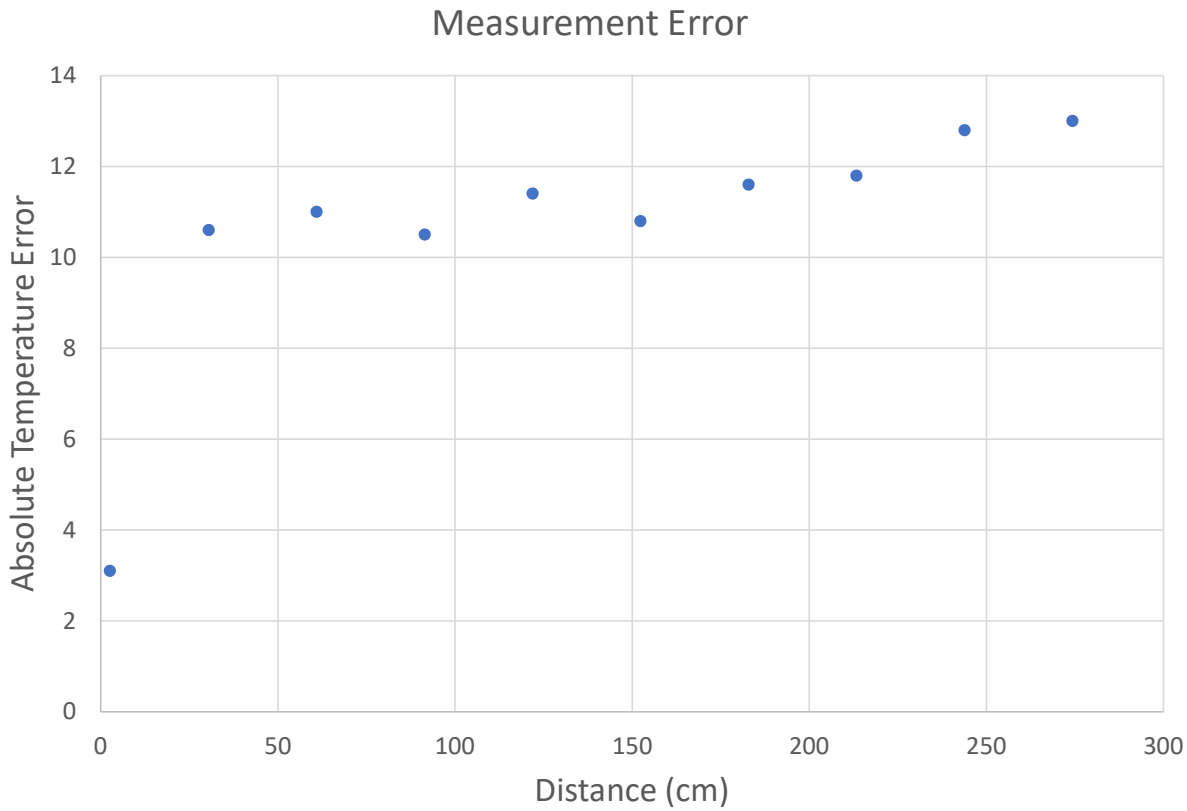
- The motor rotates the sensor to increase the effective FOV
- We decided to use a 90° sweep, which provides 16 steps of ~5.6° each
- The maximum measured pixel value is utilized



Error Modeling



Error over Distance



Future Work

- More robust infrared sensor (our budget-friendly D6T was not precise enough for realistic applications)
- Artificial intelligence to discriminate between different children
- Proximity sensor so that temperature can be modeled according to distance
- Mobile app integration
- Other applications (i.e., smart security camera)

Demo