DEPARTMENT OF MECHANICAL ENGINEERING

Lump Detectives
Breast Cancer Detection Test Apparatus

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Motivation, Goal, Impact

Motivation
- Every year, over 2 million people are diagnosed with breast cancer globally, and nearly 670,000 individuals die from the disease [1].
- Based on data from the World Journal of Clinical Oncology approximately 36% more diagnoses in low and middle income countries are Stage III or IV compared to high income countries.

Goal
- Increase early detection and screening access for women globally.
- Create a low cost and low tech solution for breast cancer screening in developing countries.

Impact

With the device used in 20 communities throughout Ethiopia, 43% more people could be diagnosed with breast cancer based on screening statistics in developing countries.

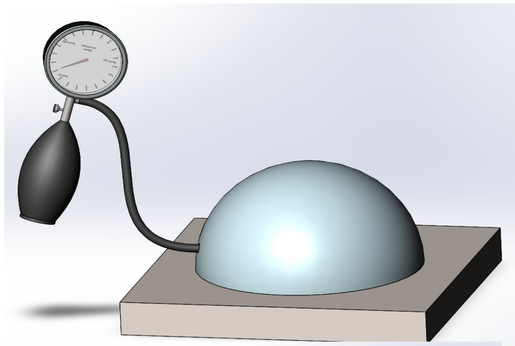
[1] WHO, Breast Cancer, March 2024

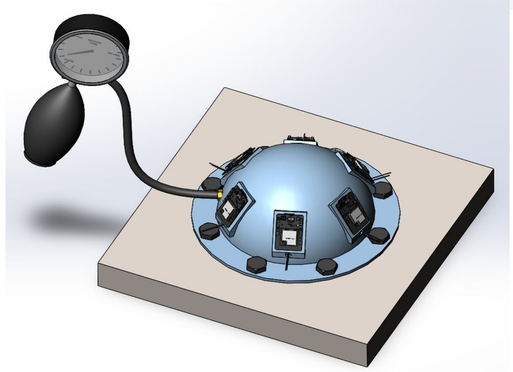
Requirements

- Technology for breast cancer detection based on optical images of the tissue under increasing air pressure
- Detect cancerous lumps of size 2 cm or greater
- Accurate (few false positives, false negatives)
- Rapid measurement

The core functionality of the testing apparatus must be integratable into a wearable form factor in future design iterations. A wearable form given the target users must also be:

- Low cost.
- Operable by untrained personnel.
- Acceptable to patients and healthcare providers.





Final Design

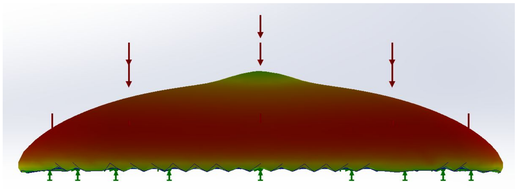
Pressurization:
- Dual dome design
- Hand pump and pressure gauge for precise measuring
- Flexible medical tube and a brass barb to allow for material replacement if needed
- Inner dome is sealed using a gasket, creating an airtight seal
- Air is pumped into the dome and tissues compresses, allowing masses to rise to the surface

Image Capturing:
- 6 ESP32-CAMS
- 6 LEDS
- Electrical components sequence one at a time
- Photos captured before and after pressurization
- Images transmitted over camera wifi

Image Processing:
- The photos are overlaid to gather mass properties
- Code is used to identify and flag masses

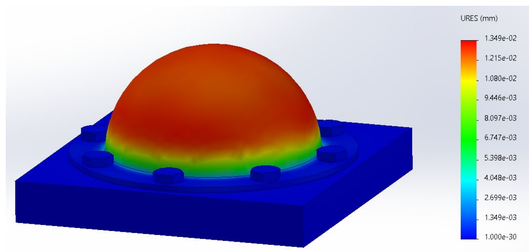
Results:
- Results are determined based on image processing
- Icons are shown to portray next steps
  - 😃✅ (Healthy)
  - 😟🏥 (Seek medical help)

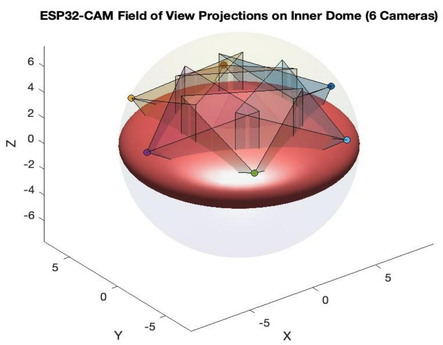
Design Calculations & Decisions



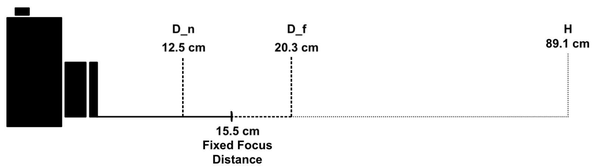
Pressure Range and Pressure to Cause Protrusions
- A minimum pressure to show a 200 µm protrusion of 20 mmHg was found using SolidWorks simulations.
- A maximum pressure limit of 190 mmHg was determined based on medical norms in mammography and blood pressure tests.

Bolts and Gasket
- To maintain uniformity of pressure, 8 0.5 inch bolts are required based on bolt spacing specifications.
- Based on ASME Unfired Pressure Vessel Code, Section VIII, Division I, a 0.5 mm thick VMQ silicone gasket will be used to create an airtight seal.
  - Low compression set, high Shore A hardness





Cameras and Lights
- Lights place 5 cm above the edge of the dome
- 6 cameras used to capture the entirety of the breast
- Lenses added to the cameras, increasing their focal range
- FOV vertical =65.5˚



Prototype & Test Results

Pressurization

- Using an acrylic base plate, closed cell foam gasket, and M4 machine screws, a pressure and seal of 250 mmHg was reached.

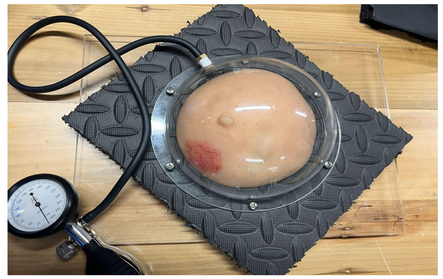
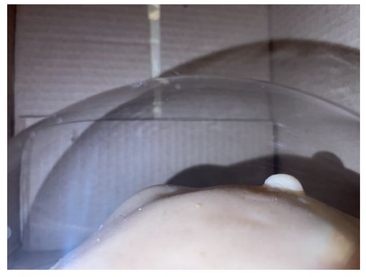
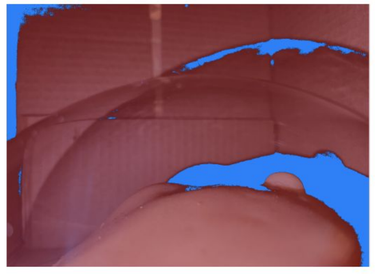


Image Capture and Processing



Original Image



Shadow Traced Image

Image with ESP32-CAM

- Once the image is captured, MATLAB is used to enhance the contrast and isolate the shadows, using a combination of color intensity and texture
- The code colors the shadows in blue, and the rest of the image in red to make it very clear where the shadows are
- From there, the program will compare the topography of the shadows present in both pictures against one another to determine mass presence and severity.