A device for early stage detection of diabetic foot ulceration

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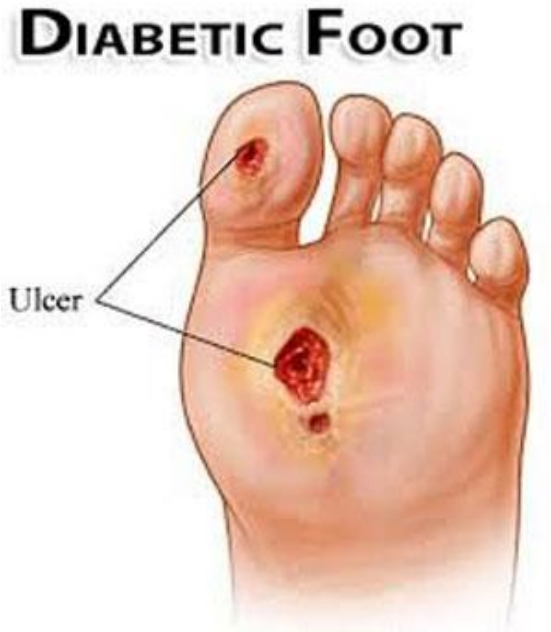
Problem Statement



https://texarkanaemergencycenter.com/9-common-dangerous-diabetes-complications/

- 60 million diabetic patients in India [Kaveeshwar, 2014]
- Patients suffer from peripheral neuropathy
    - Ulceration/amputation
- 2.2 ℃ temperature difference associated with ulcer formation [Fraiwan et al, 2017]
- Early-stage detection using thermal imaging
- Separate high-risk from low-risk patients

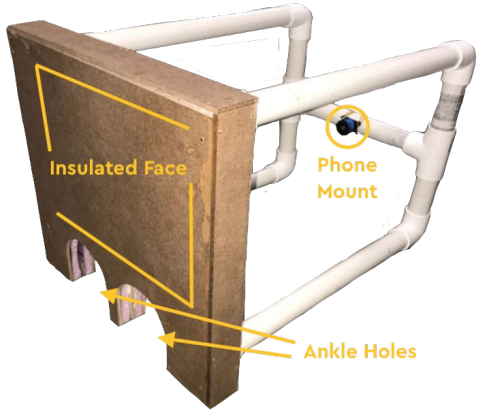
Project Background

- Others have done similar work [Liu, 2015]
- Typically done in America
  - Much more money in healthcare
  - Looking for low cost detection method
- Looking for additional biomarkers to complement 2.2 ℃

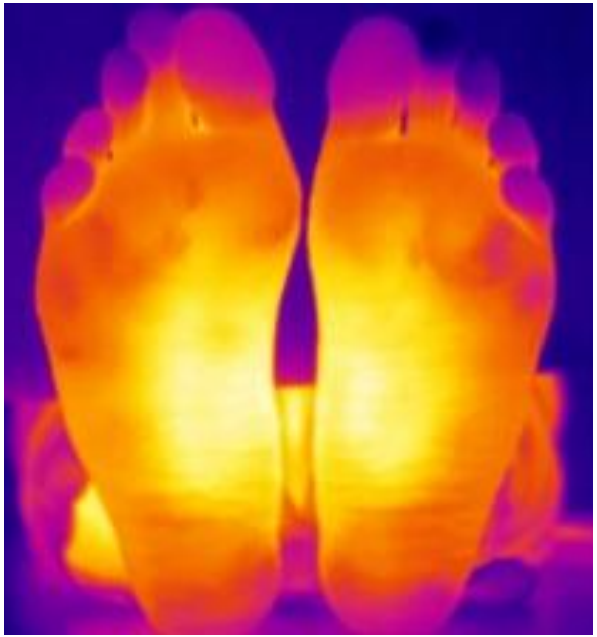
https://www.niddk.nih.gov/health-information/diabetes/overview/insulin-medicines-treatments

Last semester

- Fabricated an imaging booth
  - Insulation to eliminate noise
- Application to pick hot spots on feet
- Database for patient data



Product Design Specifications



https://healthtimes.com.au/hub/diabetes/23/news/nc1/thermal-imaging-improves-diabetes-related-foot-ulcer-assessment/3643/

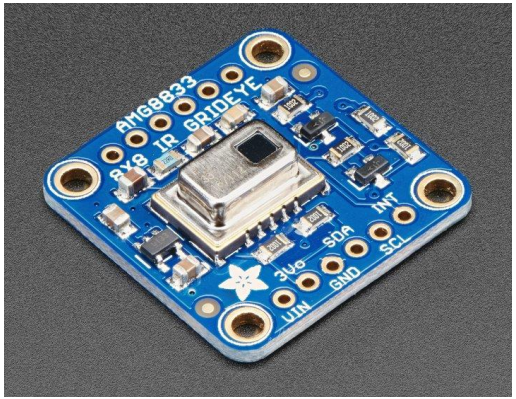
- Apparatus to standardize capturing thermal images
- Low cost (<$150)
- Transportable
- Chargeable battery to last full day
- Adequate resolution to detect hot spots

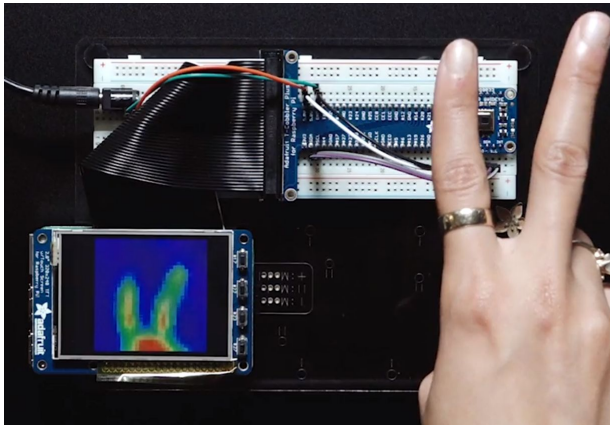
Design 1: FLIR One Camera + Phone

- 160 x 120 thermal resolution
- 1 hour battery life
- Cost: $399
- +/- 1 degrees Celsius tolerance

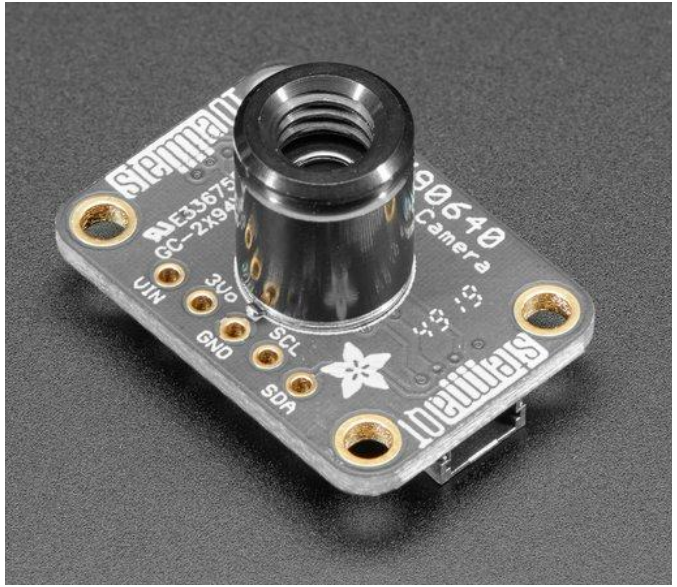
Design 2: AMG8833

- $40
- 8 x 8 grid display can be interpolated
- +/- 2.5 degrees Celsius tolerance
- 0 - 80 degree Celsius temperature range



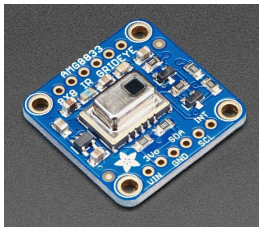
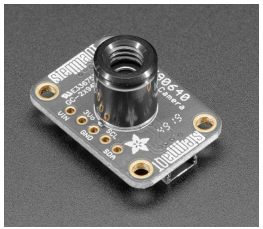


Design 3: MLX90640 Thermal Camera



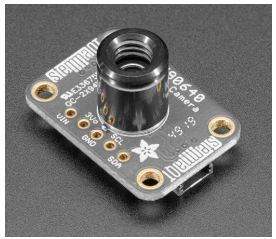
- Thermal Resolution: 32x24 pixel
- Target temperature: -40ºC - 300ºC
- Operating temperature: -40ºC - 85ºC
- Accuracy: ±0.5ºC - 1ºC for ambient temperature 0-50ºC
- Cost: $59.95

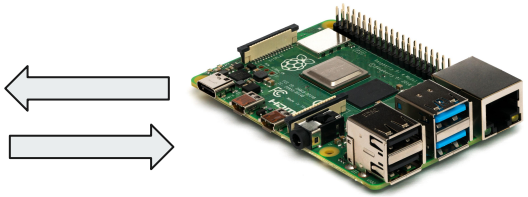
Design Matrix

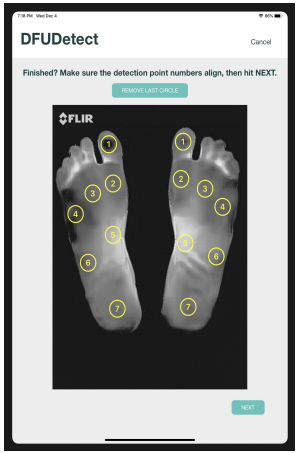
Criteria	Weight	Design	FLIR ONE Pro		Adafruit AMG8833		Adafruit MLX90640	
								
Accuracy	(15)	5/5	**15**		3/5	9	4/5	12
Resolution	(30)	5/5	**30**		3/5	18	4/5	24
Battery life	(20)	1/5	4		4/5	**16**	4/5	**16**
Cost	(30)	1/5	6		5/5	**30**	4/5	**24**
Ease of Fabrication	(5)	4/5	**5**		4/5	**4**	4/5	**3**
Totals	**(100)**		60		**77**		**79**	

Final Design: MLX90640 + Raspberry Pi

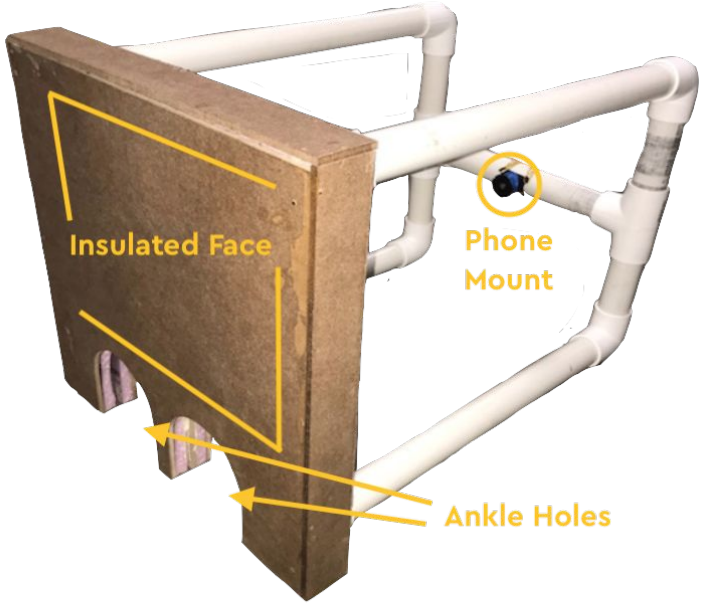
- Fabrication Process:
  - MLX —> Raspberry Pi (WiFi module)
  - Raspberry Pi —> database
  - Database —> iPad
  - Backwards connections
- Software:
  - Python + Database (Firebase) + IOS Mobile Application
- Testing:
  - Compare results to FLIR camera and current algorithm —> Goal: 90 % similar results







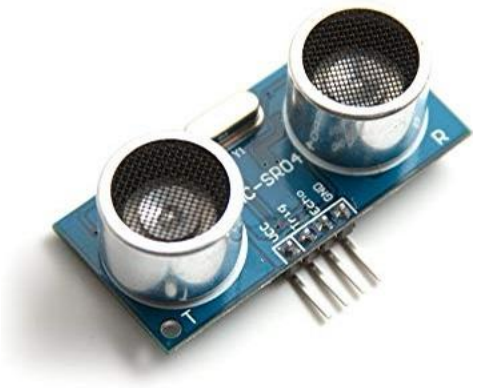
Imaging Studio Improvements



- 3D printed housing for thermal imaging electronics
- Insulated face —> thinner, lighter materials
- Move foot inserts off ground —> uniform background
- Camera to foot distance adjustment
  - Telescoping rods
  - Drawer slider

Future Work

- Add additional electronic components
  - Battery + Battery Charger
  - RGB Camera
  - Distance Sensor
  - Low res display —> real time foot alignment
- Team plans to go to India, Summer 2020
  - Applied for scholarships and in IRB process
  - Collect more patient images to improve predictive algorithms
- Software algorithms/machine learning → full mobile application



Thank you for your support

Advisor: Dr. Jeremy Rogers

Client: Kayla Huemer

Dr. Amit Nimunkar

References

[1] S. Kaveeshwar, “The current state of diabetes mellitus in India,” *Australasian Medical Journal*, vol. 7, no. 1, pp. 45–48, 2014.

[2] L. Fraiwan, M. Alkhodari, J. Ninan, B. Mustafa, A. Saleh, and M. Ghazal, “Diabetic foot ulcer mobile detection system using smart phone thermal camera: a feasibility study,” *BioMedical Engineering OnLine*, vol. 16, no. 1, Mar. 2017.

[3] C. Liu, J. J. V. Netten, J. G. V. Baal, S. A. Bus, and F. V. D. Heijden, “Automatic detection of diabetic foot complications with infrared thermography by asymmetric analysis,” *Journal of Biomedical Optics*, vol. 20, no. 2, p. 026003, Nov. 2015.

Questions?