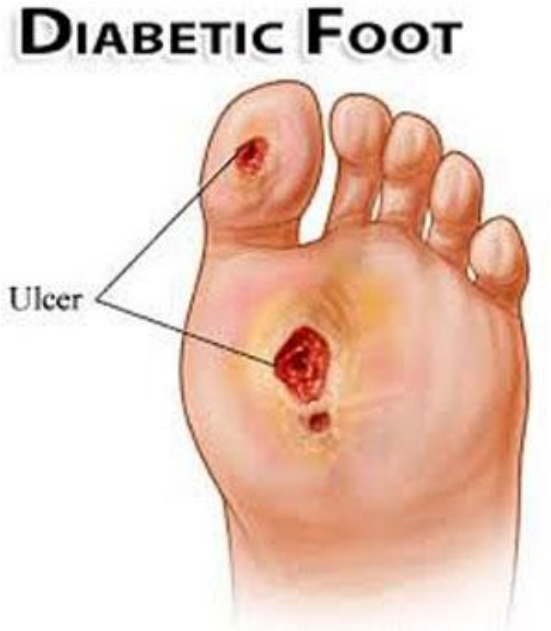
A device for early stage detection of diabetic foot ulceration

Carson Gehl, Jarett Jones, Thor Larson, Jaś Wodnicki, Kelson Rauser

Problem Statement



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

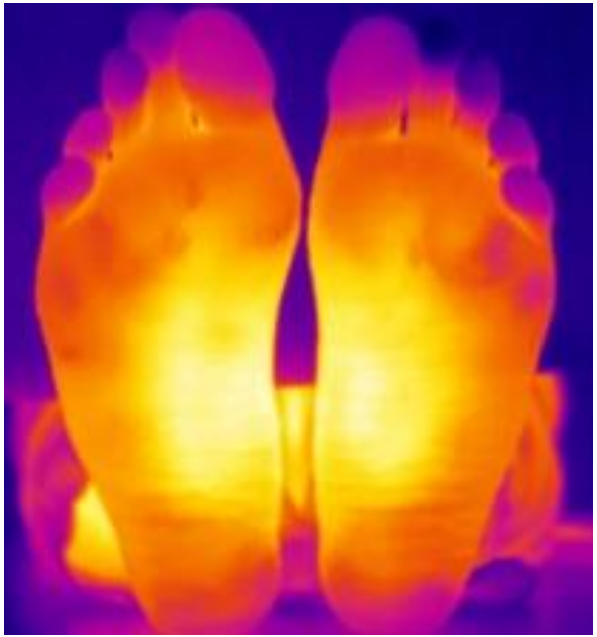
- Diabetes - over 60 million suffer in India [Kaveeshwar, 2014]
- Patients suffer from peripheral neuropathy
  - Often leads to ulceration
  - Infection ends in amputation
- 2.2 ℃ temperature increase associated with swelling/ulceration [Fraiwan et al, 2017]
- Early-stage detection using thermal imaging
  - AI algorithm to speed up diagnosis
- Separate high-risk from low-risk patients

Project Background

- Others have done similar work
- Typically done in America
  - Much more money in healthcare
  - Looking for low cost detection method
- AI algorithm for detection needed
- Lacking results from clinical trials

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

Product Design Specifications

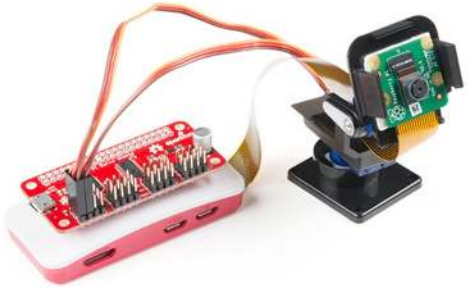


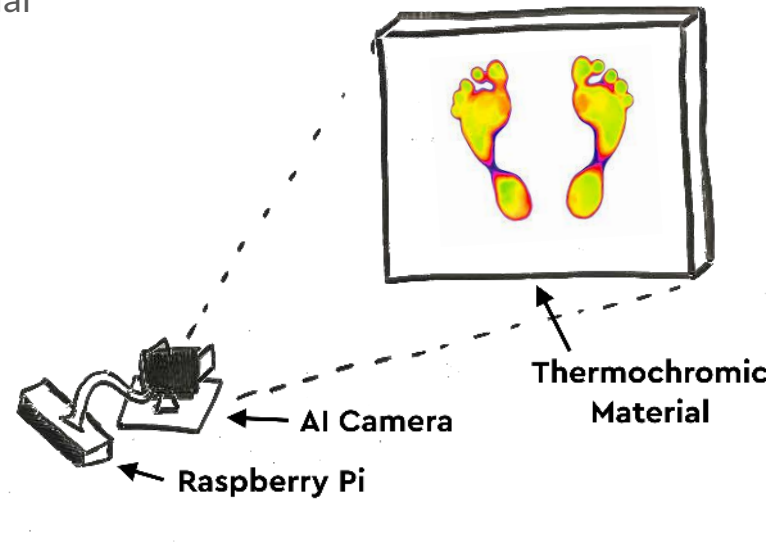
https://healthtimes.com.au/hub/diabetes/23/news/nc1/thermal-imaging-improves-diabetes-related-foot-ulcer-assessment/3643/

- Apparatus to standardize thermal images
- Software to segment photos and detect ulcers
- Low cost (<$150-300) for clinical settings
- Portable to transport around hospital
- Feasible in India

Design 1: Thermochromic Material

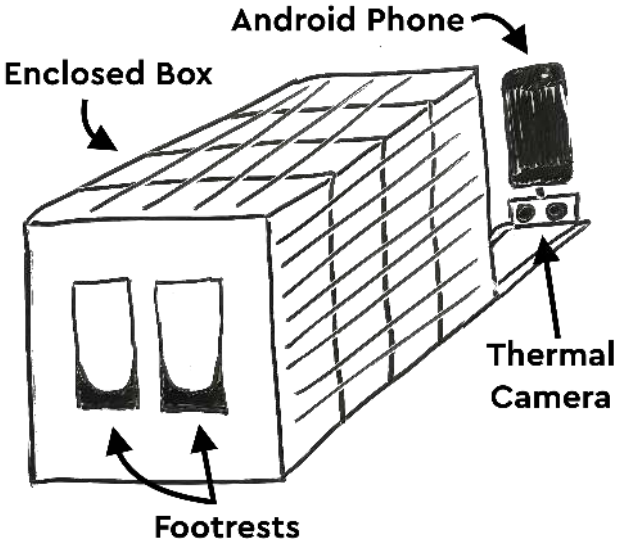
- Temperature Sensitive Crystal Sheets detect differences in temperature
- Mat Fabrication of base Thermochromic Material
- Dr. Richard Barker: Astrobotany plant Imaging
- Cost effective AI Deep Learning Mechanism

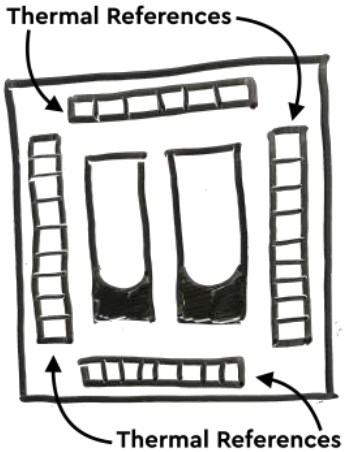




Design 2: Heat Strip Box

- Android Phone Compatible IR Camera
- Uniform Material Imaging Box
- Ankle Supported Foot Rests
- Main Goal - consistent imaging
- Thermal Reference Heated Strips
    - Calibration

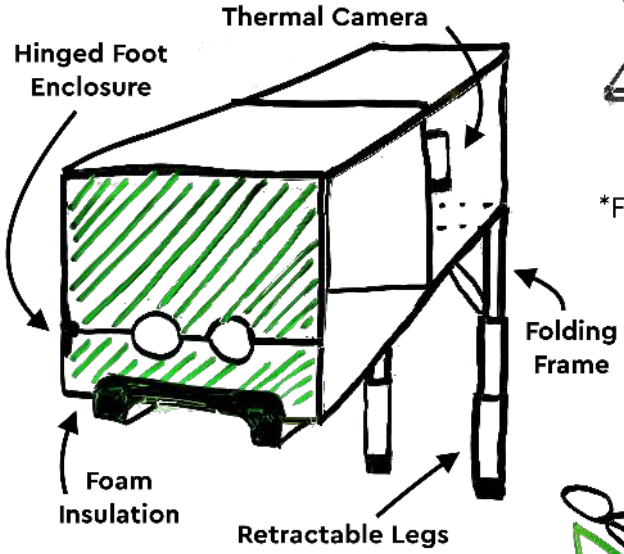


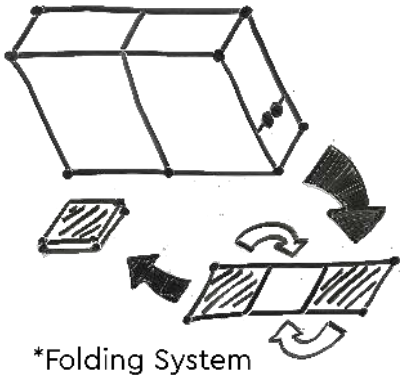


*View from thermal camera

Design 3: Insulated Folding Studio

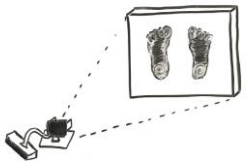
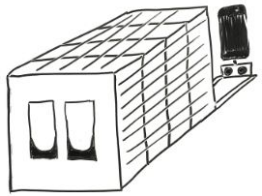
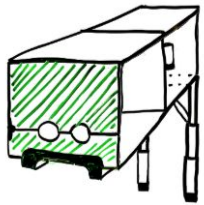
- Main Goals
  - Cost
  - Portability
- Foam Insulated Backdrop
  - Used instead of wet towel
- Retractable Legs & Folding Frame
  - Maximizes Portability
- Slightly less consistent than Heat Strip Box
  - Sufficiently accurate for data collection




*Folding System

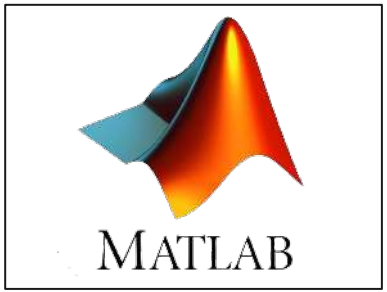

*Side view

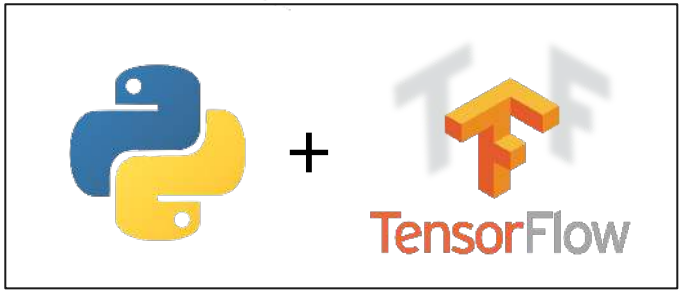
Design Matrix

Design / Criteria	Weight	Thermochromic Material		Heat Strip Box		Insulated Folding Studio	
							
Ease of Fabrication	(10)	5/5	**10**	3/5	6	2/5	4
Cost	(30)	2/5	12	3/5	18	4/5	**24**
Portability	(20)	4/5	16	2/5	8	5/5	**20**
Consistency	(30)	1/5	6	5/5	**30**	4/5	24
Longevity	(10)	2/5	4	5/5	**10**	4/5	8
Totals	**(100)**	48		72		**80**	

Software

- Image processing/Data Extraction
- Machine Learning/AI, developing a diagnosis
- Software Platforms
  - Need to integrate with FLIR SDK, mobile platform, AI processes
    - Java + OpenCV
    - MATLAB
    - Python + Tensorflow
- Combination of Java/OpenCV/Tensorflow
- Machine Learning processes
  - Supervised/Unsupervised, K-means Clustering





Future Work

- Software algorithms/machine learning → full mobile application
- Low-cost thermal camera/image acquisition device
  - Same software, test capability against current system
  - Evaluate reduced cost vs reduced resolution/accuracy
- Thermochromic mat with current software + mobile application
  - Cheap take-home “self-triage system
- Client plans to return to India, Summer 2020
  - Collect more patient images to improve predictive algorithms
  - Test thermal camera device & thermochromic mat

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.