Global Health: Prevention of Diabetic Foot Ulceration and Amputation

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Client: Kayla Huemer

Team Members

Team Leader: Cade Van Horn

Communicator: Matt Voigt

BSAC: Emma Kupitz

BWIG: Will Nelson and Carter Rupkey

BPAG: Anvesha Mukherjee

Figure 1: Team Photo - From left to right: Cade Van Horn, Anvesha Mukherjee, Will Nelson, Emma Kupitz, Carter Rupkey, Matt Voigt

Current Problem

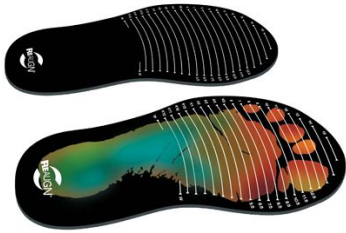

Figure 2 - [1]

- **Overall:** Prevention of diabetic foot ulceration and amputation
- **Our Problem:**
  1. Design a more cost effective way to obtain a thermal image of a diabetic's feet
  2. Analyze digital images using machine learning
  3. Create user friendly software that makes the data easy to interpret and understand

Figure 3 - [2]

Background

- High Blood Sugar causes nerve damage
- Ulcer(tear in skin or sore) forms
- Neuropathy - can’t feel the severity of the ulcer
- Easily curable if caught early
- Left untreated, may lead to amputation

Figure 4 - Damaged nerves from neuropathy in a diabetic foot [3]

Current/Competing Products

- Siren Socks
  - Monitors temperature continuously
  - Not practical in India due to temperatures
- Handheld infrared skin thermometer
  - Worried about compliance
- Team from previous semester created an imaging box
  - Not the easiest to move

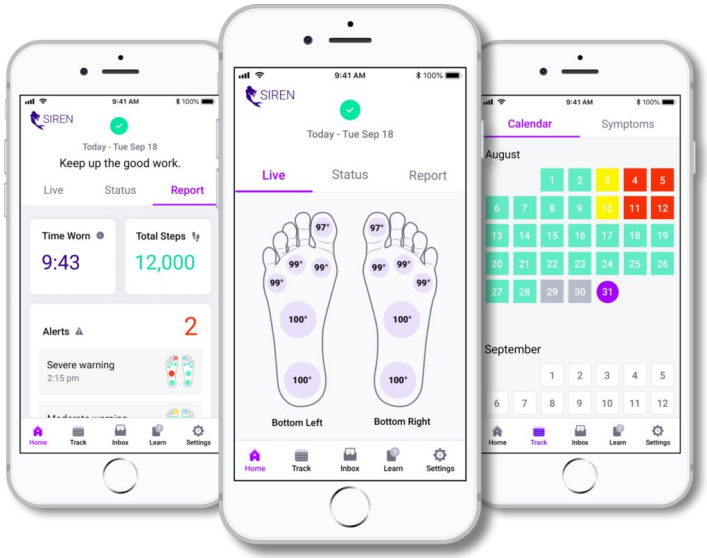

Figure 5 - Siren Socks temperature monitoring app [4]

PDS Summary

- Low-cost at-home temperature monitoring device
- Easy compliance
- Thermochromic material
- App-based software
- Machine learning algorithm
- Output risk factor for ulceration

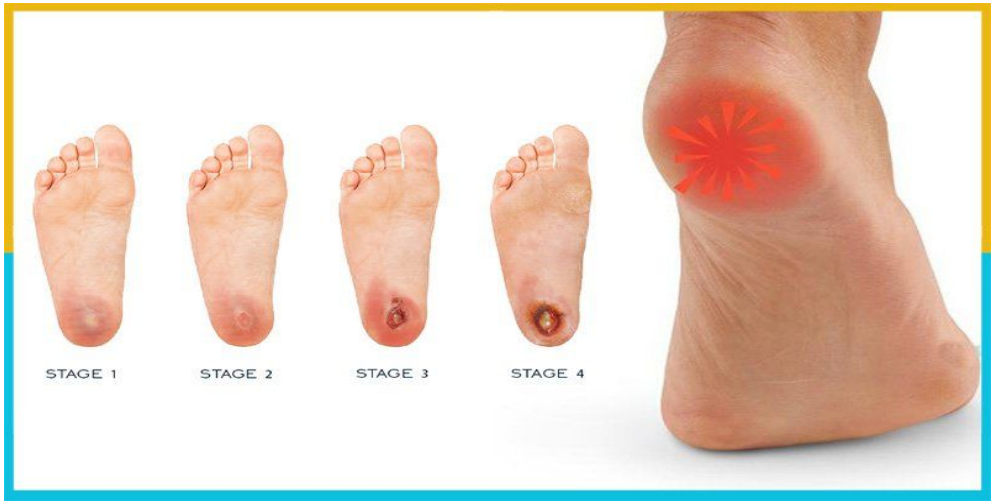

Figure 6 - Stages of Diabetic Foot Ulceration [5]

Design Ideas

Design 1: Thermochromic liquid crystal sheet

- Heat sensitive color changing sheet

Figure 7 - Thermal Camera [6]

Design 2: Thermochromic liquid crystal changing powder

- Combination of color changing powders

Design 3: Thermal Camera smartphone attachment

- IR sensing circuit component
- Connected to smartphone to take images

Figure 8 - Thermal Camera [7]

Preliminary Design 1

Thermochromic Liquid Crystal Sheet

- Readily available
- Reusable and inexpensive
- Only accurate within a small temperature range

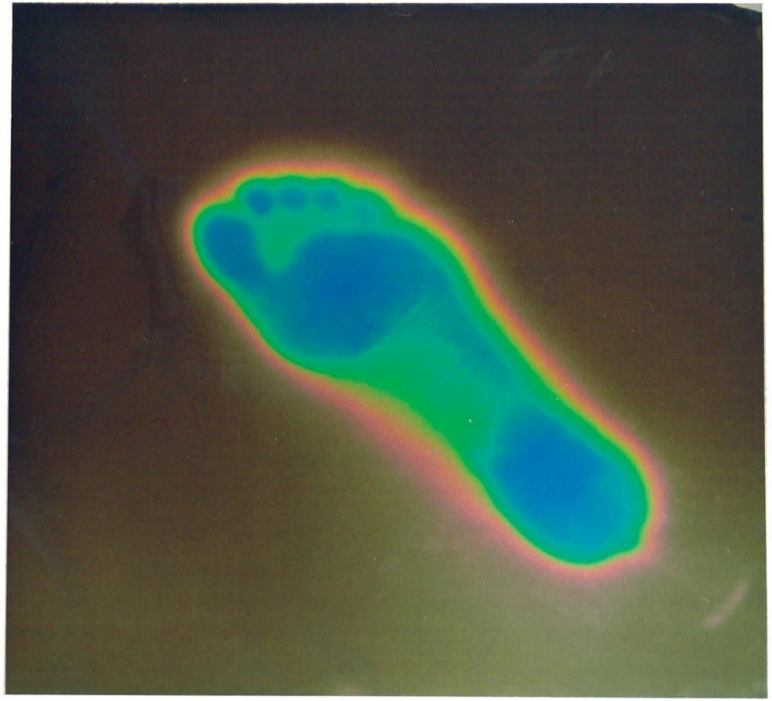

Figure 9 - Liquid Crystal Thermochromic Sheet [8]

Preliminary Design 2

TLC Powder Mixture

- Layer to increase accuracy
- Relatively inexpensive
- Requires extra coatings to increase durability

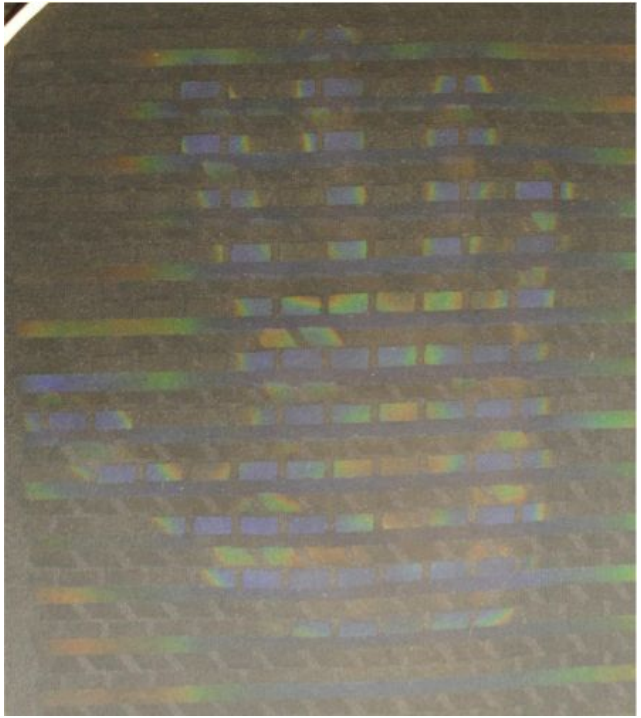

Figure 10 - Thermal image of hand using thermochromic powder dyes [9]

Preliminary Design 3

Thermal Camera Smartphone Attachment

- Potential to be extremely accurate
- Cost increases with accuracy
- Difficult to use without assistance

Figure 11 - IR Thermal Camera Smartphone Attachment [10]

Design Matrix

Table 1 - Design Matrix

			Design 1: Insulated color changing sheets		Design 2: Mix of color changing powders		Design 3: Thermal camera smartphone attachment	
Rank	Criteria	Weight	Score (10 max)	Weighted Score	Score (10 max)	Weighted Score	Score (10 max)	Weighted Score
1	Cost	20	10	20	10	20	4	8
2	Accessibility/ Compliance	20	10	20	10	20	5	10
3	Ease of Use (for patient)	20	10	20	10	20	5	10
4	Accuracy/ Sensitivity	15	3	4.5	9	13.5	10	15
5	Durability	10	8	8	10	10	10	10
6	Ease of Fabrication	10	7	7	6	6	2	2
7	Safety	5	10	5	10	5	10	5
	Sum	**100**	**Sum**	84.5	**Sum**	94.5	**Sum**	60

Chosen Design - Color Changing Powders

- Design 2: Mix of color changing powders
- Scored highest in design matrix
- Easy to use
- Combine powders onto surface
- Step on surface to get thermal image
- Upload image to software

Figure 12 - Thermochromic Color Changing Powder Dyes [11]

Potential Problems

- Securing the powders
- Ensuring the image stays
- Temperature accuracy
- Enough data for machine learning
- Fabrication and testing during Covid

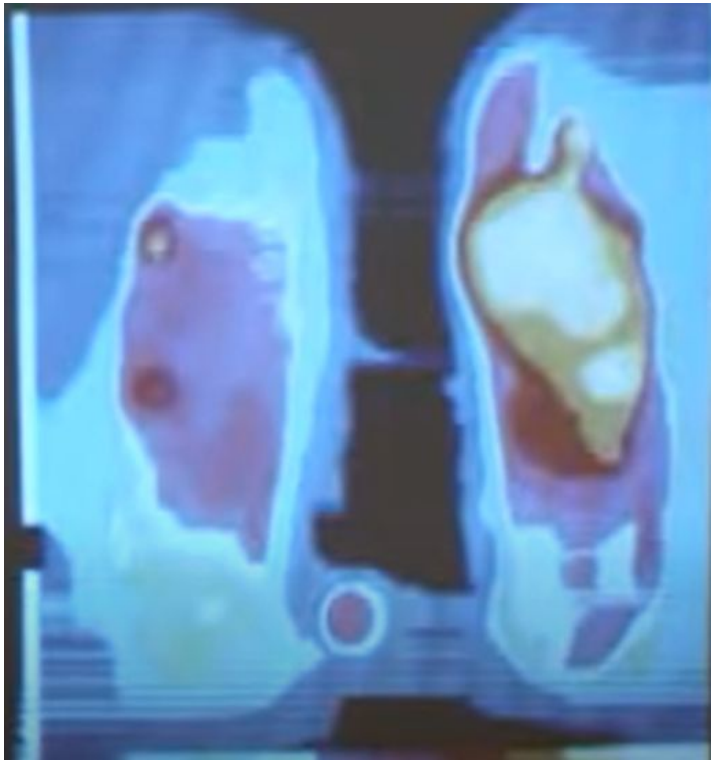

Figure 13 - Thermal image of diabetic feet with ulcer [12]

Conclusion and Future Work

- Purchase and assemble powders
- Initial testing on different surfaces
- Temperature testing for accuracy
- Machine learning algorithm

Figure 14 - Thermochromic powder used as paint [13]

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Questions?