Performing 3D Digital Image Correlation on 3D Printed Prosthetics

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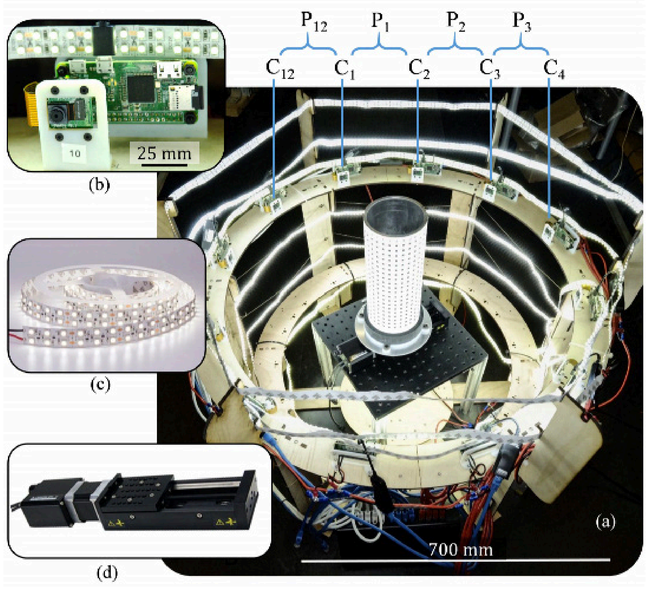

[Figure 1]:
This image, taken from MIT's "MultiDIC" paper, represents a set-up similar to one that we are trying to recreate around our Instron machine to capture the mechanical deformation of sockets [1].

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INTRODUCTION

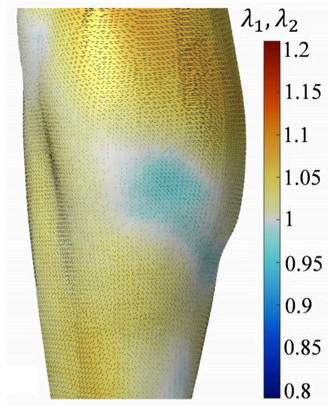
Project Lim[b]itless aims to develop an affordable and accessible method for scanning residual limbs and designing sockets to create trans-tibial prosthetics for amputees around the world.

- Specifically, the aims of the Electrical Engineering subteam are to design a rig to be built around an Instron machine in order to capture videos to analyze the mechanical behavior of 3D printed sockets through 3D digital image correlation (3D-DIC).

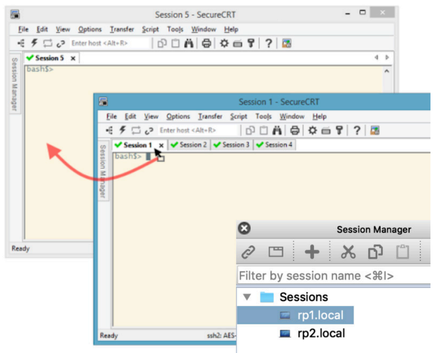
OBJECTIVES

This sub-team's goal is to create an affordable set-up around an Instron machine using multiple Raspberry Pi boards to capture video and process data for the mechanical testing of sockets.

- In order to perform 3D-DIC, the set-up must capture 360 degrees of video to recreate a 3D rendering of the socket. See **[Figure 2]** for similar example.
  - ◊ Videos from each camera must be captured simultaneously without lag in order to accurately record deformation of the socket.
- The rig must be set up in a way that optimizes the cameras' positions in order to record videos with enough overlap between any two sets of cameras.
  - ◊ The angles between each camera pair must be calculated to allow enough overlap to ensure that the 3D image can be recreated.



[Figure 2, left]:
Created from the 12 cameras in Figure 1's set-up, this image is a 360 degree reconstruction of an individual's calf with colors mapping the principal stretch values [1].



[Figure 3, right]:
Using SecureCRT, we are able to SSH into multiple Raspberry Pi's at once and simultanously send commands to record videos of the socket being tested in the Instron machine. Here, you can see that we have connected to two Raspberry Pi's (rp1.local and rp2.local) at the same time.

RESULTS

- We were able to simultaneously access Raspberry Pi boards through Secure Shell (SSH) using an Ethernet hub. **[Figure 3]**
  - ◊ Our current set-up uses 20 Raspberry Pi 3B+ boards. **[Figure 4]**

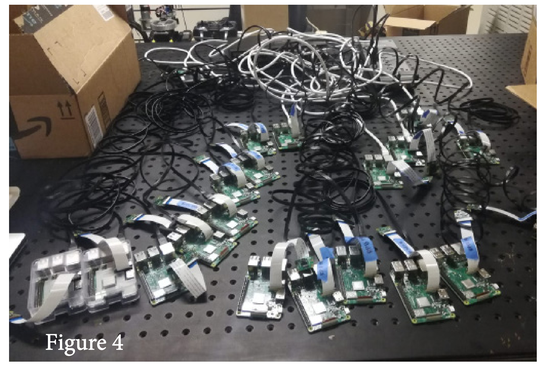


Figure 4


Figure 5

- A synched, 20 camera set-up using Raspberry Pi 3B+ boards will facilitate the simultaneous 360 degree video recordings of the socket.
- An initial cardboard prototype of the frame of the rig was built to test out distances and measurements of the cameras before proceeding onto a higher fidelity model. **[Figure 5]**

CONCLUSION AND FUTURE GOALS

We have been able to access and send commands to all 20 of the Raspberry Pi 3B+ boards through SSH and an ethernet hub connection. A Raspberry Pi Zero W is being used as a clock reference for all the 3B+ boards to receive commands and record video simultaneously. A cardboard frame for the rig has been built to test out the 3D DIC system and to allow adjustments to the heights and distances of each component before building the actual frame around the Instron machine.

- Our next step is to focus on debugging the code that controls all the Raspberry Pi's and to minimize the delay between each board.

- We will mount the cameras onto the prototyped frame for the rig in order to start testing the 3D DIC and adjusting the positions of cameras.
  - ◊ When the locations and distances of the Raspberry Pi's are optimized, we will move onto building the final rig around the Instron machine.

REFERENCES

[1] Solav Dana, Moerman Kevin M., etc al. "MultiDIC: An Open-Source Toolbox for Multi-View 3D Digital Image Correlation."
Retrieved from: https://ieeexplore.ieee.org/document/8371235