Quantification of Movement in Guinea Pig Model of Sudden Cardiac Death Using Machine Learning

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Introduction

- Sudden cardiac death is the largest cause of natural death in the United States, resulting in roughly **325,000 deaths annually**[1]
- It is responsible for 30-50% of all deaths for people with Heart Failure
- The most common scale for quantifying Heart Failure the New York Heart Association (NYHA) Functional Classification, which classifies Heart Failure by the degree to which physical activity is limited
- To study Sudden Cardiac Death, the Neurocardiology Lab at the University of Cincinnati College of Medicine utilizes Guinea Pigs that have undergone a procedure that induces Heart Failure
- The development of a Heart Failure classification system in a Guinea Pig model would provide insight into the progression of Heart Failure and its link to Sudden Cardiac Death

Hypothesis

- Guinea pigs that have induced heart failure exhibit decreased activity levels compared to normal Guinea Pigs

Objectives

- Development of a **machine learning algorithm** to quantify animal activity using video data
- Development of **hardware and cage setup** that facilitates accurate collection of data

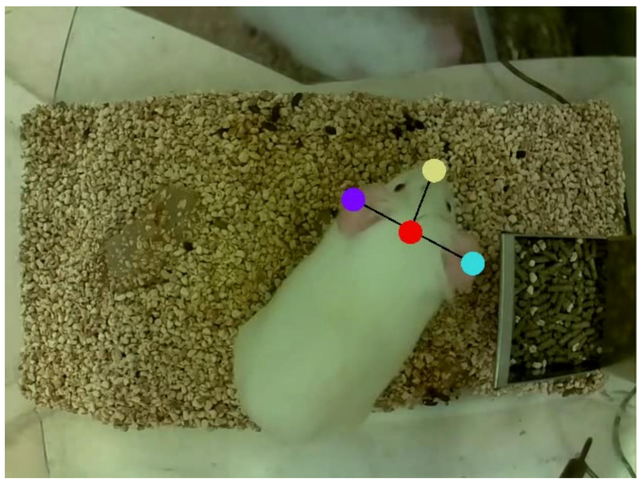
Methods

- Videos were recorded with an Arducam Day-Night Camera connected to a Raspberry Pi CanaKit 4
- Videos were recorded at 30fps, with a resolution of 480x640 pixels
- To track animal movement, a software package called **DeepLabCut**[2] was used
- To create an animal tracking model in DeepLabCut, sample videos were obtained that depicted the animal in a diverse range of positions
- Then, **specific points on the animals' bodies were labeled** from frames obtained from those sample videos
- Labeling more frames from a more diverse dataset results in more accurate tracking
- Once frames were labelled, DeepLabCut "trained" the model for a user-specified number of iterations
- Running the training for more iterations also results in more accurate tracking
- Once the model was trained, independent videos were recorded and run through the model, and **DeepLabCut output videos with the desired body parts labeled**, along with a .csv file that contained the x-y coordinates of each labeled point for every frame of the video
- The .csv file also output the confidence that the model correctly identified the desired body part in each frame of the video

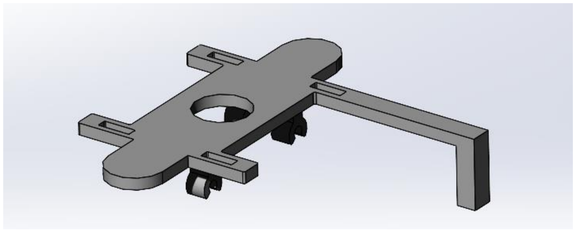
Results

Cage setup showing upper section of cage inserted into normal cage to raise camera height so entire cage floor can be in camera field of view (left) and aerial view of cage with camera attached (right)

Frame from labeled video of normal Guinea Pig showing effective tracking of left ear, right ear, tip of nose, and center of head



3D Model of camera fixture that clips onto metal bars on cage top and holds camera in consistent x, y, and z position and has slots for Velcro straps to secure camera



- The **cameras were securely attached to 3D-printed fixtures** and attached to the metal grill on top of the cage, **providing aerial view of entire cage**
- A DeepLabCut tracking model was created by labelling approximately **450 frames** from three 60-minute videos of normal Guinea Pigs and three 60-minute videos of animals that have undergone the procedure to induce Heart Failure
- On each frame, the left ear, right ear, tip of nose, and center of head were labeled to determine which body part had the highest tracking confidence
- The model was trained for **50,000 iterations**, with the **tracking confidence** for each body part as follows:
  - Left ear: 35.6%
  - Right ear: 43.6%
  - Tip of Nose: 48.3%
  - Center of Head: 50.4%
- By using the .csv file data to calculate the change in position for each frame and then converting the distance in pixels to meters, the total distance traveled by the animal for the duration of the video was calculated
- For one normal animal, calculating the change in position of the center of head in each frame resulted in a distance of **68.57m traveled in 30 minutes**

Conclusions

- A machine learning model was created that successfully tracks and quantifies Guinea Pig movement
- The modifications to the cage and camera setup facilitate accurate data collection
- Future studies can use this system to compare activity between treatment groups and study the effect of heart disease on activity over time

References

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2. Mathis, M., Mamidanna, P., Abe, T., Cury, K., Murthy, V., Mathis, M., et al. (2018). Markerless tracking of user-defined features with deep learning. *Nature Neuroscience, 21,* 1281-1289.

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