Using 3D markerless pose estimation programs to determine fear reactivity in human infants.

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Introduction

- Development of Fear Reactivity
  - Fear begins developing in infants around 6-8 months of age.
- Assessments of Fear Reactivity
  - When assessing the level of distress in an infant, there should be few confounding factors for child discomfort. Using a markerless pose estimation program allows for less contact between the researchers and the subjects, decreasing these confounds.
- Why use 3D markerless pose estimation programs?
  - Graduate students spend countless hours hand-labeling and coding videos for behavioral analysis; by using an automated markerless pose estimation system, that time is significantly reduced.

AIMS OF THIS STUDY

1. Determine whether OpenPose or DeepLabCut works best to automate label placement on infants during behavioral assessments.
2. Using positional data, determine direction of infant gaze during behavioral assessments
3. Overall Goal- be able to use videos to assess whether attention to fearful visual stimuli will correlate with fear reactivity.

Methods

- 22 Infants were subjected to an Adapted version of the Mask Episode from the Laboratory Temperament Assessment Battery (Lab-TAB) manual.
  - The adapted mask episode involved an individual entering the room wearing four different Halloween masks (apple, horse, alien and monkey) and recording the infant's reaction.
  - Videos of infants were coded for fearful behavior by research assistants at University of North Carolina at Chapel Hill (UNC).
- Variables used to determine fear reactivity:
  - UNC Coder Ratings: Facial Fear, Vocal Distress, Bodily Fear, Startle Response, Escape Behavior.
  - Granular Measures: Frequency and duration of gaze towards mask, mother, or away during assessment, measured by human raters.
- Pose Estimation Systems:
  - OpenPose (OP) is a neural network that has already been exclusively trained on humans (Figure 1A).
  - DeepLabCut (DLC) was originally trained using animal models, however our team trained DLC by hand annotating ~3,000 frames (Figure 1B)

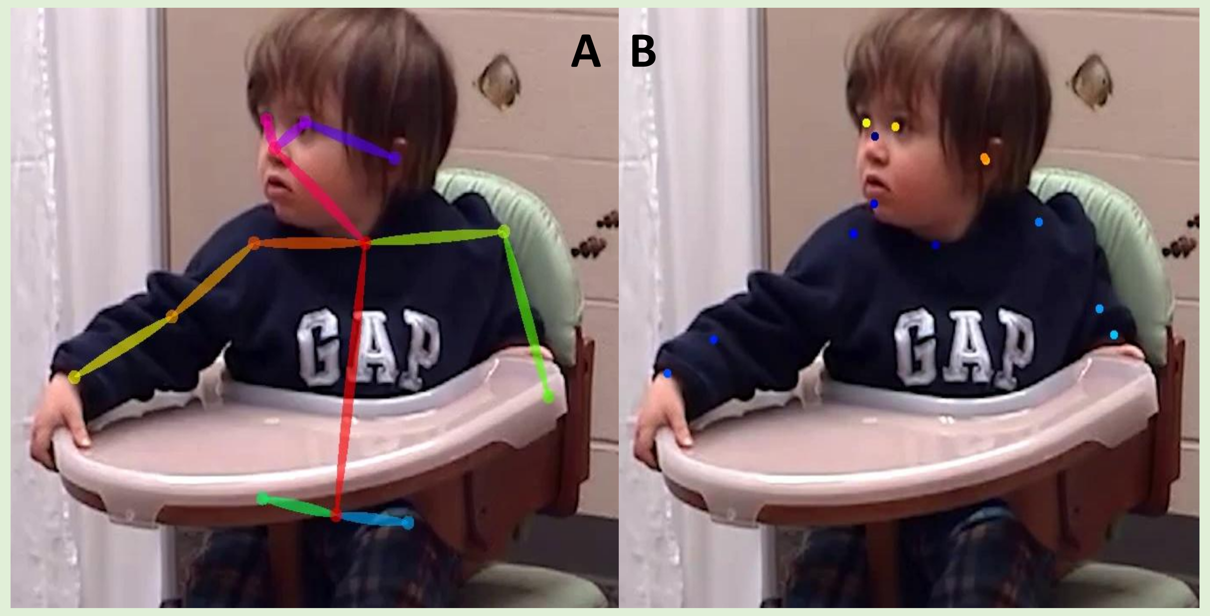

Figure 1: Example of labels that are placed using OpenPose (A) and DeepLabCut (B)

Results

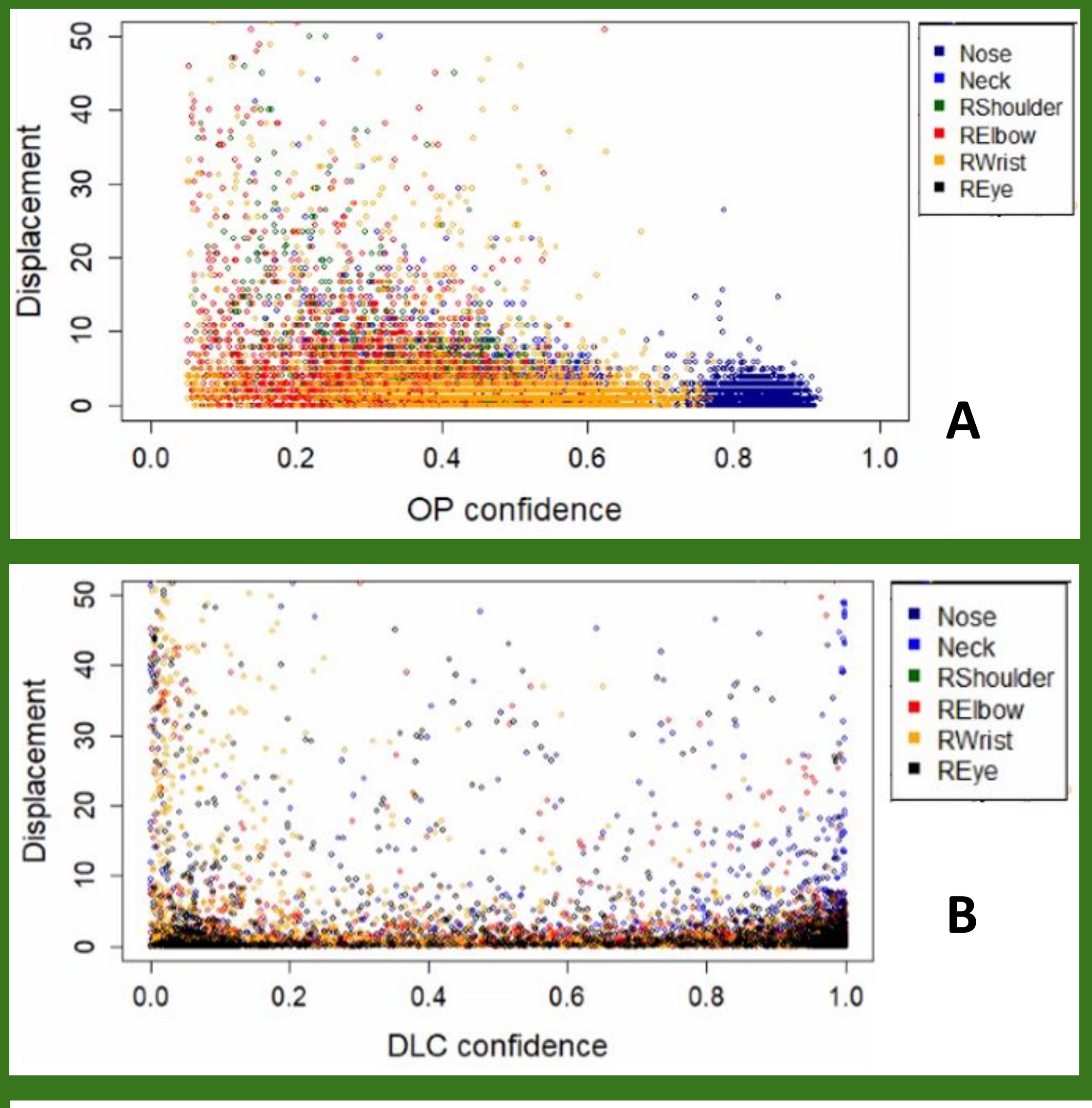

Figure 2: Accuracy of confidence measures for each pose estimation program. Shows the displacement of points (the distance between an annotation placement and the next frames placement of the same key feature in pixels) over the confidence values that OpenPose and DeepLabCut provide to estimate the accuracy of annotations.

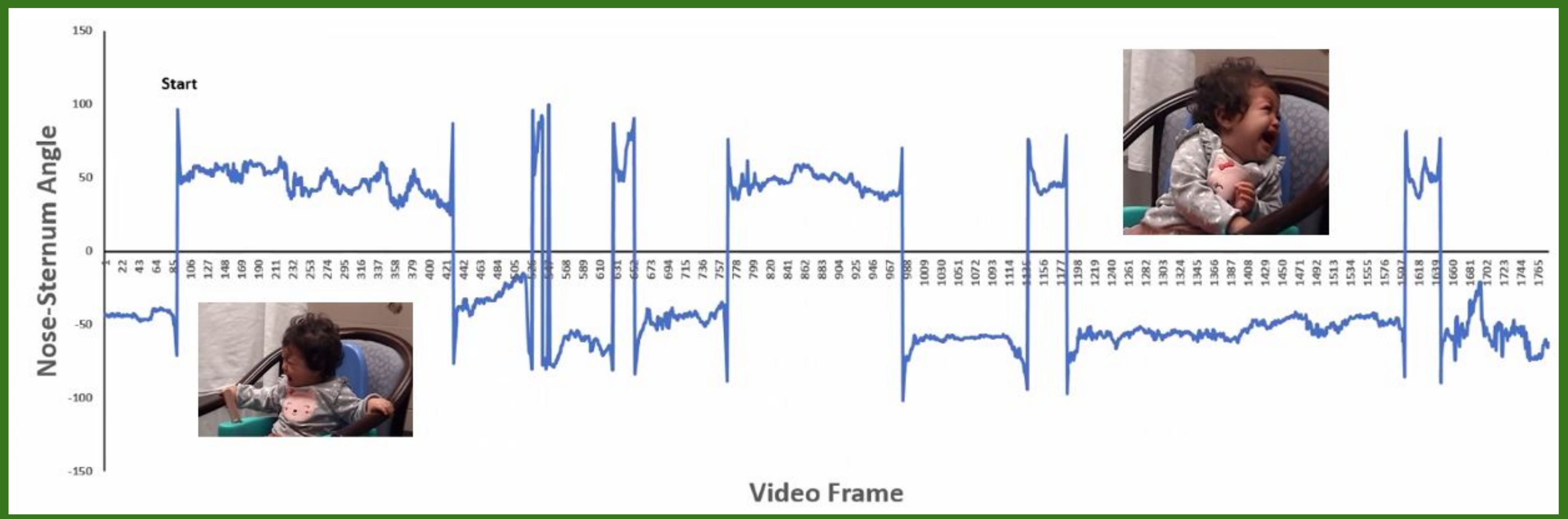

Figure 3: Tracking of infant gaze using positional data gathered by OpenPose for subject MA002. Gaze direction was calculated by taking the midpoint between the right and left shoulder (sternum) and calculating the angle between the sternum and the nose of the subject. Negative angles correspond to times the infant was looking over their shoulder at their mothers while the positive angles represent when the infant is facing toward the mask.

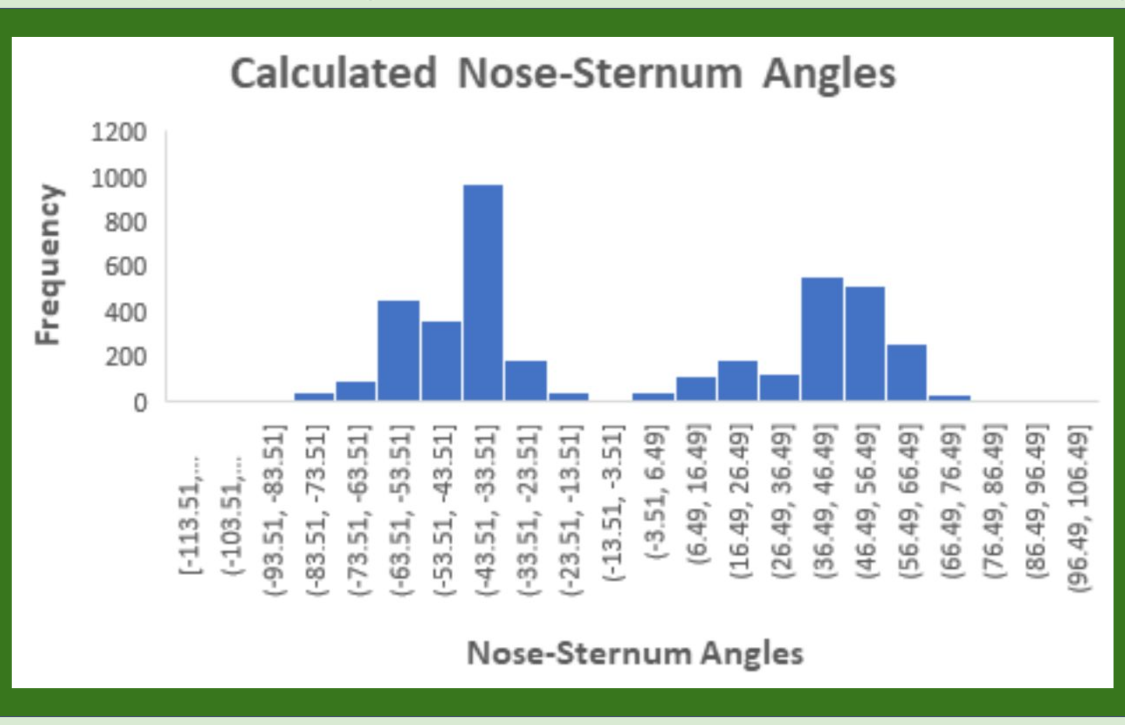

Figure 4: Histogram of angles calculated between nose and sternum. Two distinct groupings are shown, the left grouping (negative angles) are when the infant is looking back at their mother while the right grouping (positive angles) are when the infant is looking in the direction of the mask.

Discussion

- DeepLabCut vs OpenPose?
  - We determined that OpenPose would provide the most accurate positional annotations in a quick manner.
    - OpenPose shows consistency in annotations along with confidence values that best represent error (Figure 2)
  - DeepLabCut had points that it was 80% or more confident in the placement of, but had extremely high displacements which leads us to believe that the confidence measures given by DLC are not accurate at this point.
    - This was especially evident in the nose, suggesting that training DLC with more infants may allow for more accurate confidence assessments
- Infant Gaze Tracking
  - The angle between the sternum and nose were calculated for each video frame.
  - Frames that had sternum-nose angles < 0 were determined to be when the infant is looking back at mother.
    - Escape behavior
    - Other possibilities include the infant looking toward mother for comfort or seeing if mother is also afraid of the mask
  - Frames that had the sternum-nose angle > 0 were determined to be when the infant was looking at the research assistant wearing the Halloween masks.
    - Prolonged holds or “freezes” upon seeing the mask are typical responses of bodily fear.
  - By plotting the frequency of the angles we were able to see two distinct groups of angles (Figure 4).
    - We noted that the infant MA002 looked more frequently over their shoulder at their mother than in the direction of the mask.

Conclusion

- OpenPose was selected to be the most accurate and efficient markerless pose estimation program when compared to us manually training DLC neural network
- Assessment of gaze direction may give us objective insight into how infants attend to or escape from fearful stimuli.

Next Steps

- Compute correlation between assumed escape behavior (turning around to look at mother) and granular measures showing infant looking at mother.
- Determine if prolonged pauses/”freezes” in one infant gaze angle is correlated with tensing or bodily fear

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