

Automated Detection of Infant Holding and Carrying Behaviors via Body-Worn Motion Sensors

Xuewen Yao^{1,2}, Thomas Ploetz¹, McKensey Johnson², Kaya de Barbaro²

¹Georgia Institute of Technology, ²The University of Texas at Austin



National Institute
of Mental Health

TEXAS
The University of Texas at Austin



MHR
INSTITUTE for MENTAL HEALTH RESEARCH

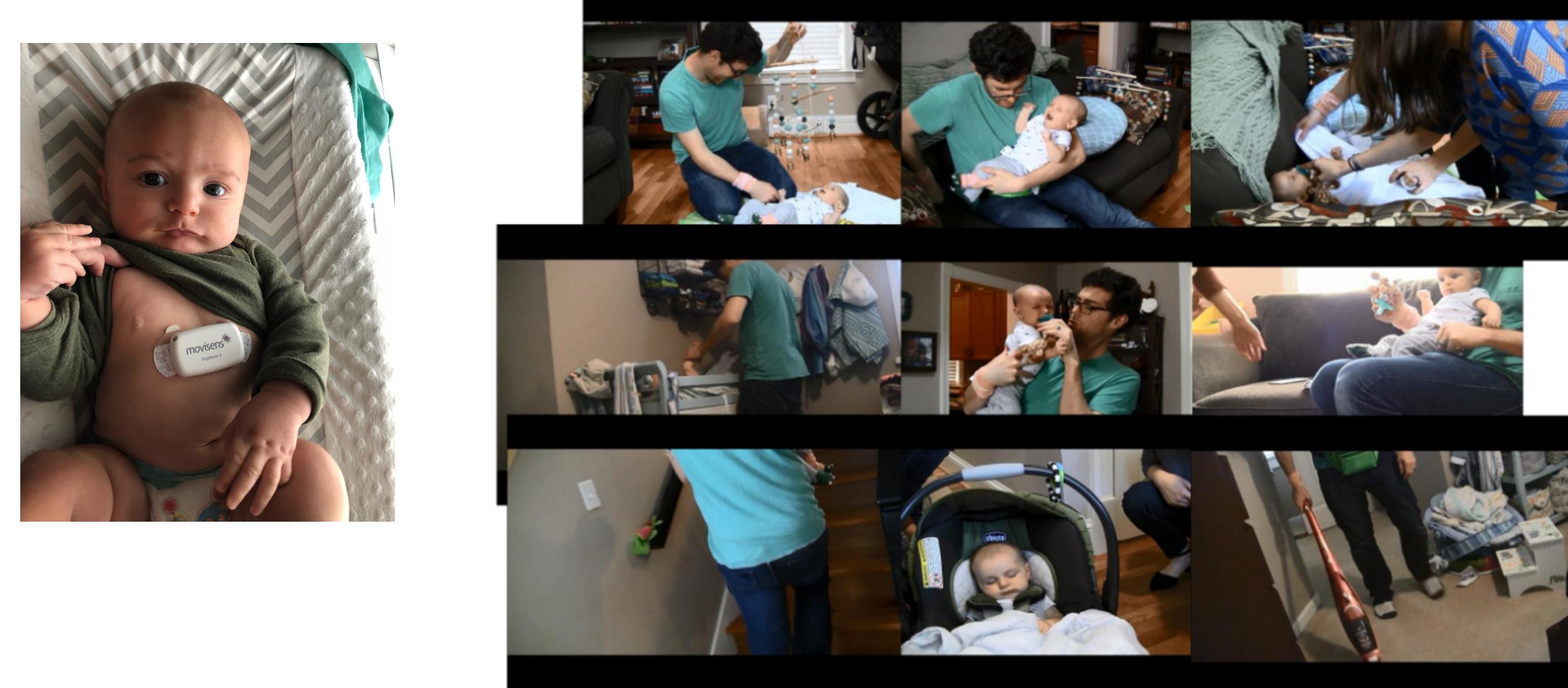
Background

Current methods for studying physical contact and touch are limited to direct observation or self-report. This means we have little understanding of the *natural variation* in physical contact across families and its broader impacts on child development.

In this poster, we demonstrate the possibility of using wearable motion sensors to automatically detect holding behaviors between caregivers and their infants.

Our goal is to apply this model (coupled with other sensors) to extended (24-72h) daily data to examine the long-term interaction and attachment between caregiver-infant pairs.

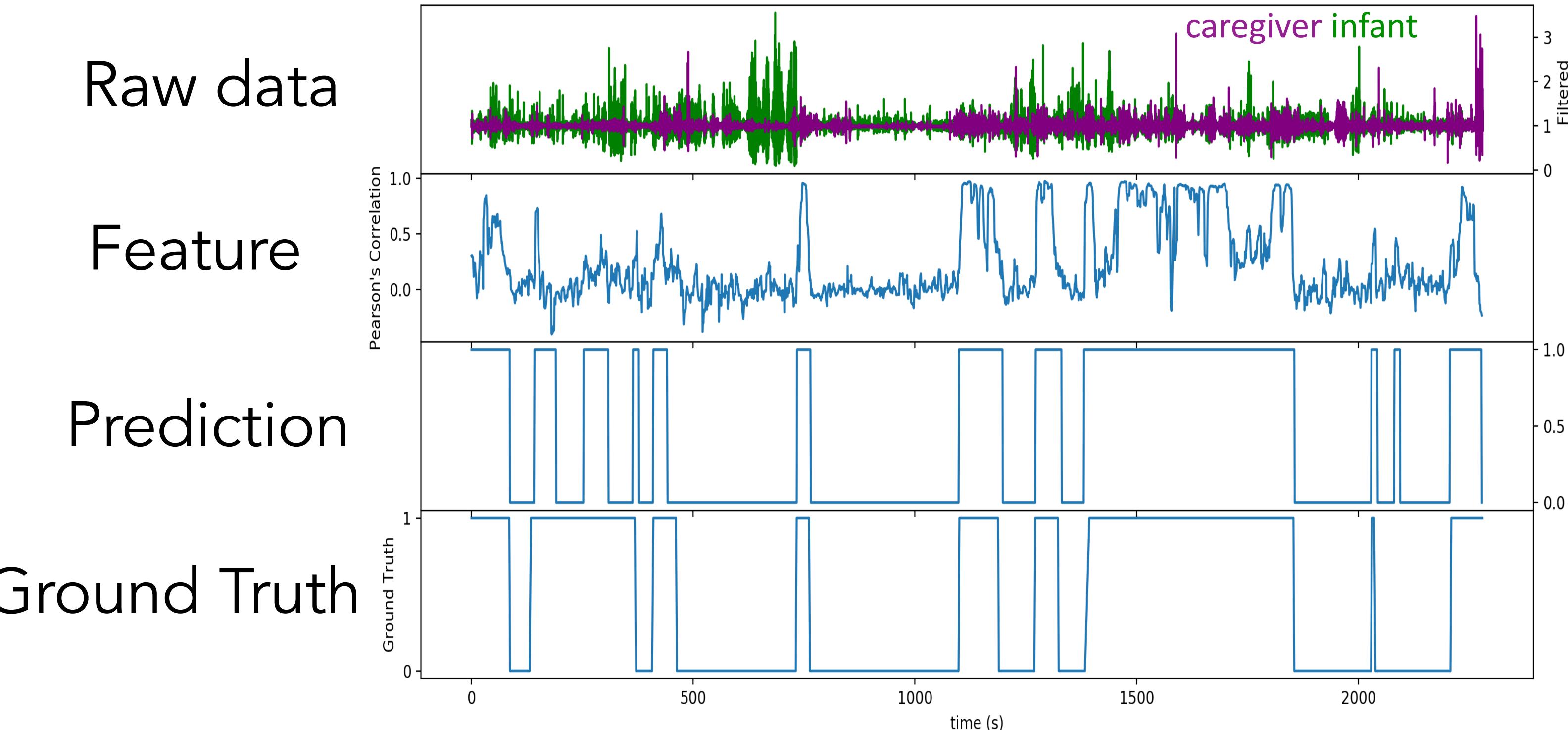
Collection of training data



Activity recognition requires an organized and consistent labelled dataset for training and testing.

- **Sensor:** 3-axis acceleration at 64 Hz using Movisens EcgMove 3 [1]; caregivers and infants wearing one sensor on their chest
- **Protocol:** a 5-minute standardized "free-play" task; 5-to-7-minute "reactivity assessment" [2] and "around-the-house" task (10-20 minutes).
- **Participants:** 26 healthy mother-infant pairs; infant (10 females and 16 males) average age 5.3 months (std: 2.78, range: 1.23-10.8); mom average age 30.96 (n: 24, std: 3.71, range: 24-39); 14 mothers identified as White, 3 as Hispanic, 3 as African-American, 1 as Asian, and 5 as Multiracial.
- **Annotation:** Trained RAs annotated a binary category of holding and not holding across the entire recorded session (Mean: 45 minutes, SD: 11 minutes, kappa = 0.844) at second-by-second resolution. Mothers held their infants on average 41.4% of the session (std: 0.130, range: 0.163 - 0.744), which was about 18.6 minutes for an average 45-minute session.

Automatically detecting holding from mother-infant motion data



Activity recognition pipeline

- Collect and annotate samples of natural holding activity
- Motion data preprocessing and windowing
- Motion data feature extraction
- Machine learning (Random Forest Model) to map labels to features (leave one participant out cross validation)
- Post-processing of prediction results through smoothing.

Results of 4 different assessment scenarios

We show our results in 4 different assessment scenarios.

- Second-by-second accuracy
- Contingency of holding within every 2-min window
- Prediction of absolute holding time
- Event accuracy (frequency of holding episodes)

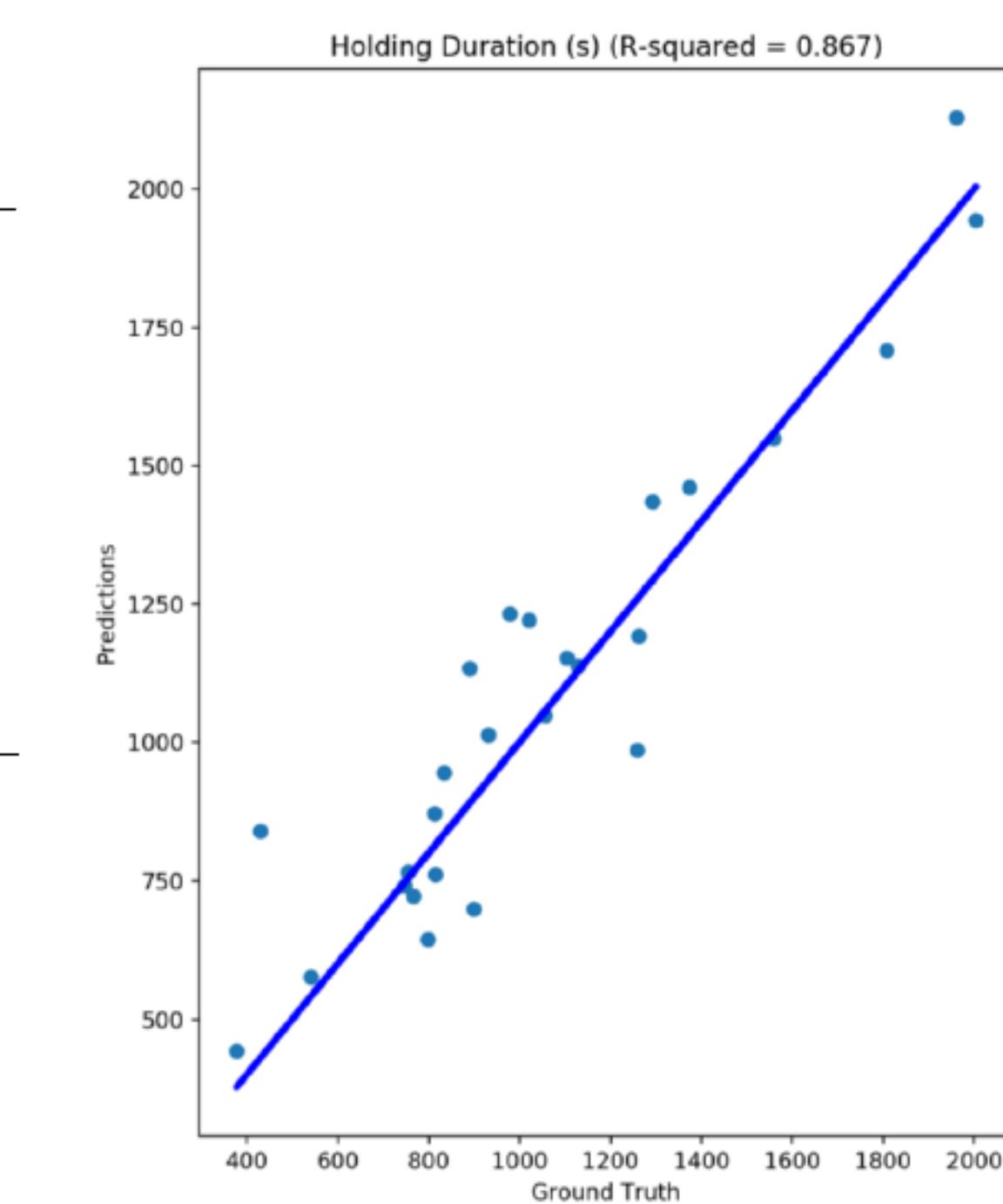
Second-by-Second Accuracy

	Accuracy	F1 Average	Holding precision	Holding recall
Mean	0.870	0.831	0.818	0.854
Std	0.059	0.091	0.105	0.102

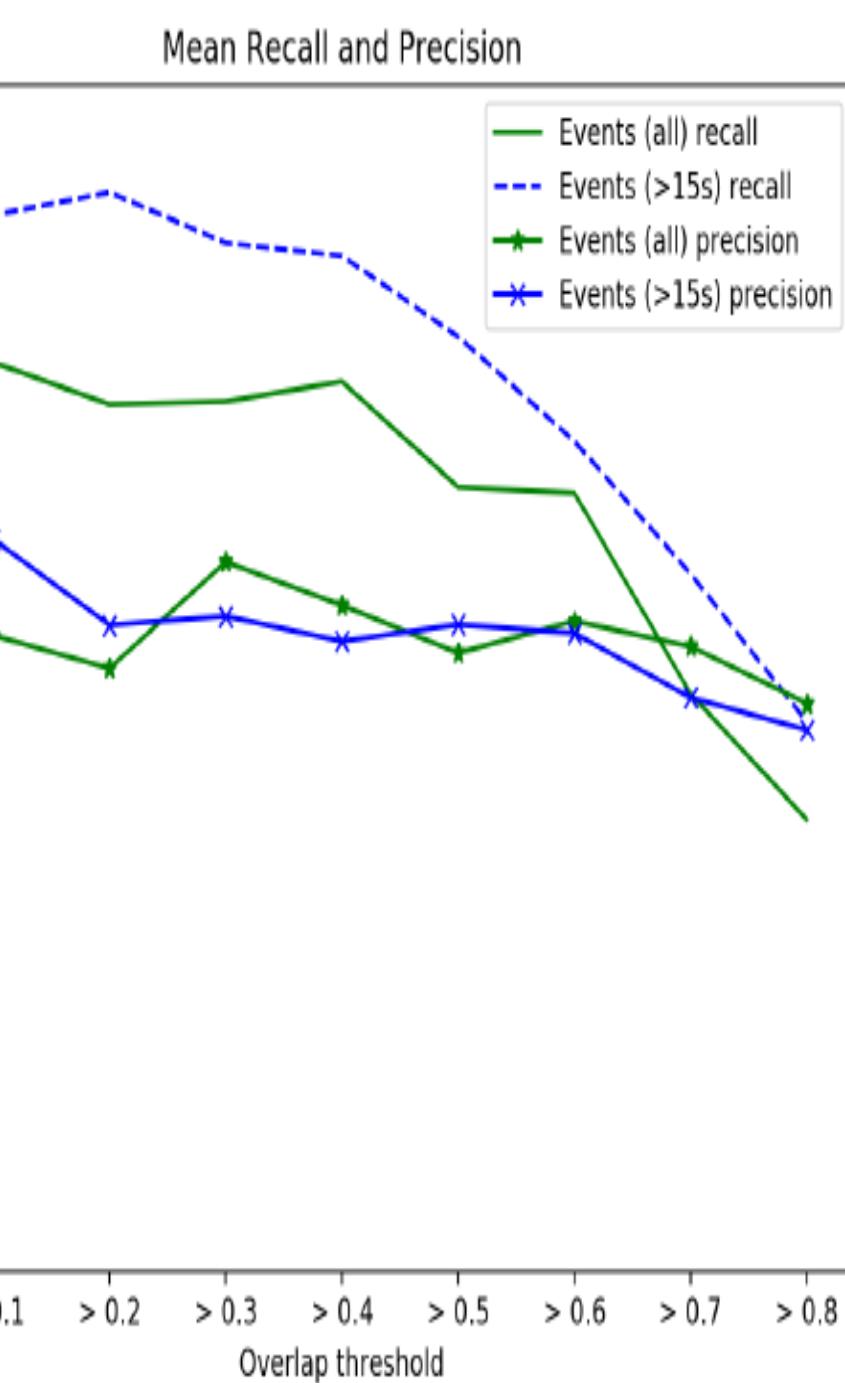
Contingency of holding

	Session	Accuracy	F1 average	Hold Precision	Hold Recall
Mean	0.855	0.894	0.855	0.944	
Std	0.081	0.067	0.088	0.069	

Prediction of absolute holding time



Event Accuracy



Discussion

- We successfully developed a model for precisely and objectively characterizing patterns of holding in naturalistic interactions and evaluated it on 26 mother-infant pairs and achieved adequate accuracy in all assessment scenarios.
- The model features timing and duration of holding episodes and could be used to predict relevant child and caregiver outcomes ranging from stress system neurobiology and attachment security to maternal mental health symptoms.
- Similar to LENA system [3], our model could be incorporated into interventions designed to increase holding frequencies and durations by providing families with objective feedback

References & Works Cited

We thank the National Institute of Mental Health (NIMH) for funding, Prof. Sherryl Goodman of Emory University for her guidance and our families and students for participation.

- [1]. Movisens. ECG and Activity Sensor - EcgMove 3. www.movisens.com/en/products/ecg-and-activity-sensor-ecgmove-3
- [2]. Kagan, J., Reznick, J. S., & Snidman, N. (1987). The Physiology and Psychology of Behavioral Inhibition in Children. *Child Development*, 58(6), 1459. doi:10.2307/1130685
- [3]. LENA. www.lenab.org