# Visualizing Classroom Social Networks of Hearing Impaired and Non-impaired Children with Real-time Automated Measurements

**Leon Lei[1], Samuel Cooper[2]**
**Brown University[1], Fayetteville State University[2]**

UNIVERSITY OF MIAMI DEPARTMENT of COMPUTER SCIENCE

UNIVERSITY OF MIAMI CENTER for COMPUTATIONAL SCIENCE

UNIVERSITY OF MIAMI DEPARTMENT of PSYCHOLOGY

## INTRODUCTION

- Communication disorders such as deafness and autism pose significant obstacles to children's language development and social relationships.
- This study is among the first to integrate data on both child location and child vocalization to better understand peer and child-teacher interactions in the classroom.
- Through a novel approach to data analysis and visualization, this study offers preliminary insights that can inform and shape future research on children's social networks.

**Figure 1**: (from left) Ubisense tag, vest worn by children that holds LENA and Ubisense devices, LENA audio recorder

## DATA COLLECTION

- 7 approximately 4-hour observations were collected on a weekly basis over the course of two months (March, April) from the Auditory/Oral Education Program of the Debbie School at the University of Miami Mailman Center for Child Development. Subjects were 7 deaf / hard of hearing (DHH) children and 3 typical hearing children between the ages of 2 and 3, as well as 2 teachers.
- Child location and orientation were measured with Ubisense using four sensors placed in the corners of the classroom that track active (radio impulses emitting) tags worn by children. Language use was measured with LENA (Language ENvironment Analysis) audio recorders and software to quantify target child, other child, and adult vocalizations, and to detect child-teacher conversational turns (Figure 1) .

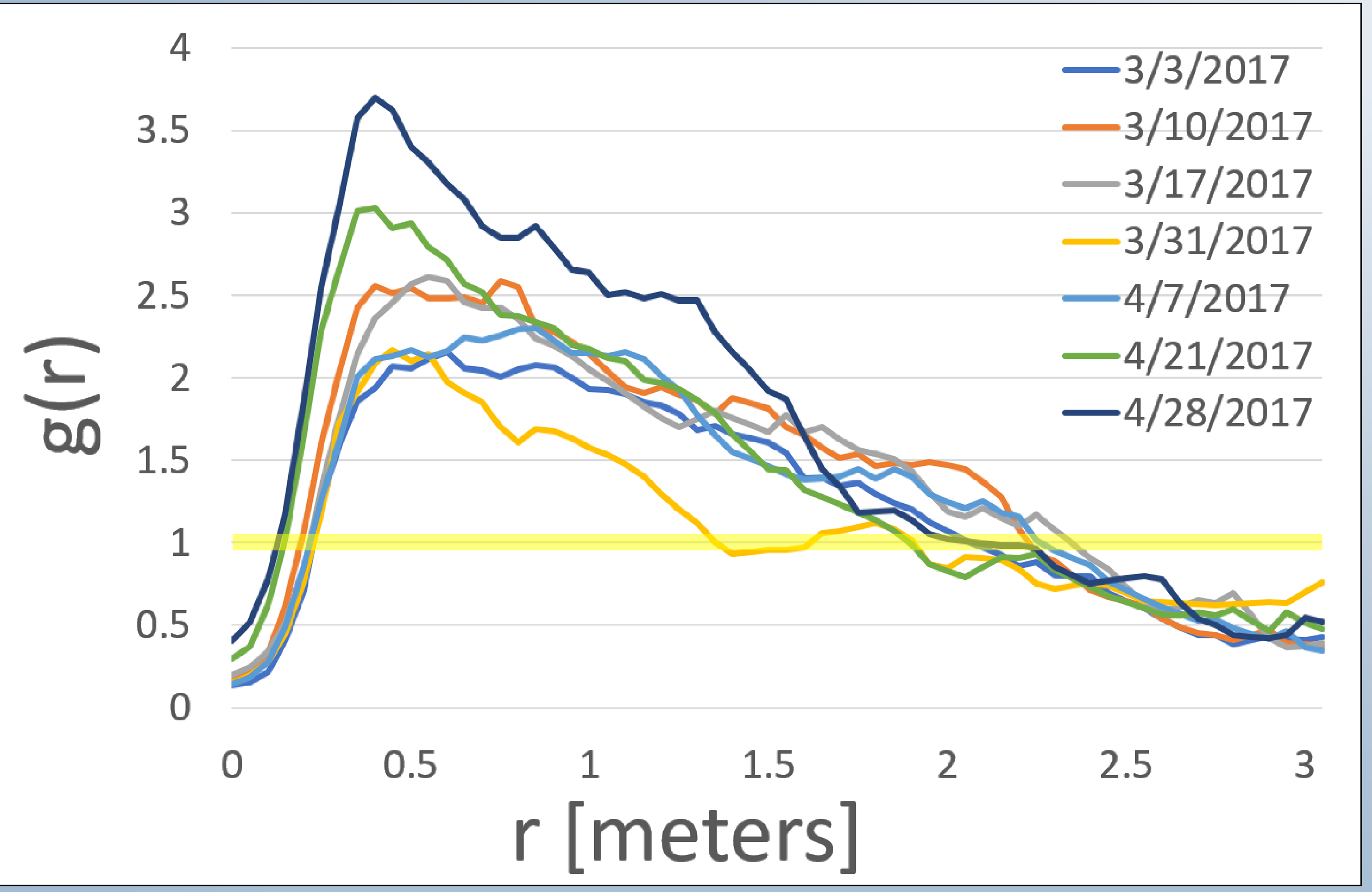



**Figure 2**: The radial distribution function, *g(r)*, indicates distances at which the probability of two children being in contact is higher than chance; in the null-model case *g(r)* = 1.

## METHODS

- Raw Ubisense and LENA data were processed as CSVs with code written in C# (Microsoft Visual Studio 2017). Data was converted to a 0.1 second time resolution by means of a linear interpolation over all data points.
- C# code was also used to generate the GML (graph markup language) files which serve as inputs for Cytoscape, an open source software platform used to visualize social networks.
- A force-directed algorithm was applied to the layout of all networks, in which the weights of the edges affect the positions and proximity of the nodes.
- Static and animated visualizations, i.e. plots and movies, were created with both Microsoft Excel (2016) and Matlab (R2017a).

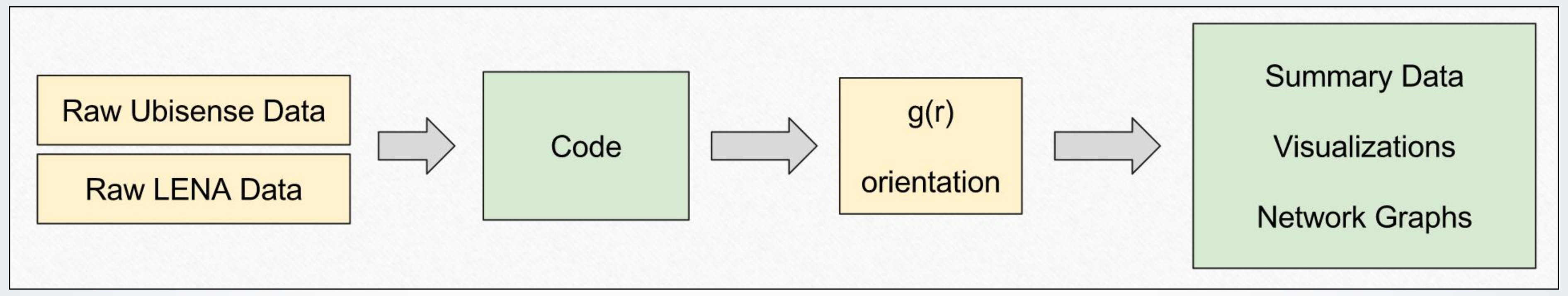
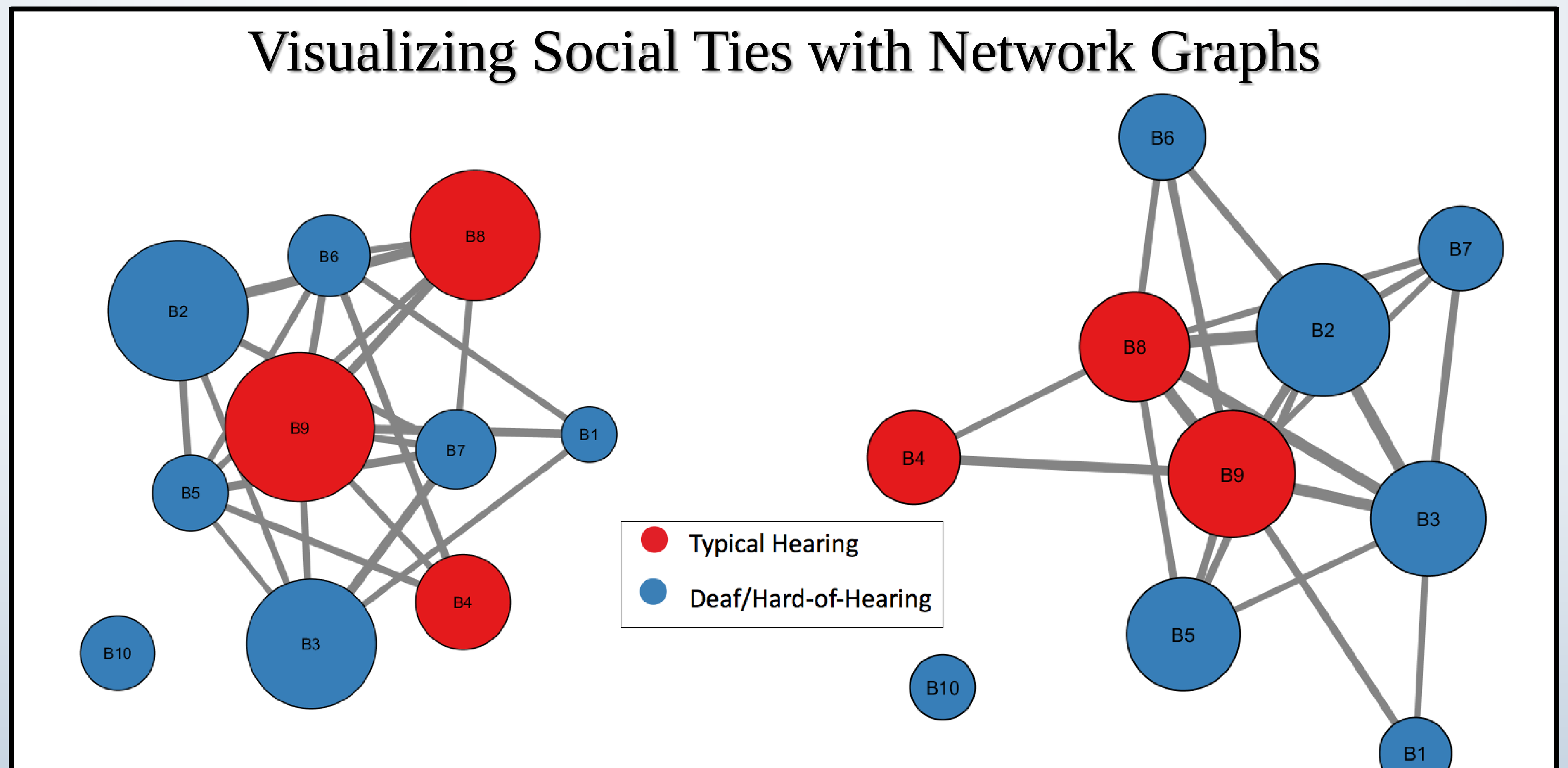



**Figure 3**: Pipeline for data processing and visualization

## RESULTS

- From the location data, a null-model of random child movement within the classroom was constructed (Figure 2).
- After processing data (Figure 3), social networks were constructed for two different parameters (child-teacher turn counts and peer co-talking) for each of seven recording days, then aggregated over all recorded observations and repruned (by mean) for visual clarity.

### Visualizing Social Ties with Network Graphs




**Child-Teacher Turn Counts**

We identified when pairs of children were within *g(r)*=1.5m and oriented within 45° of each other. The width of each edge was set proportional to the amount of contact between the pair of children, and the size of the nodes was set proportional to the total turn counts of an individual over that recording day.

**Peer Co-Talking**

We defined two children as co-talking if they were within 1.5m and either child talked. The width of each edge was set proportional to that pair's co-talk duration, and the size of the nodes was set proportional to the sum of each individual's co-talking with all other partners.

**Figure 4**: Force-directed, aggregated networks of all observations for two different parameters.

- Snapshots can be created at any time during the observation period to a 0.1s resolution (Figure 5).
- Combining these snapshots continuously produces "real-time" movies of the classroom day, reconstructed from data.

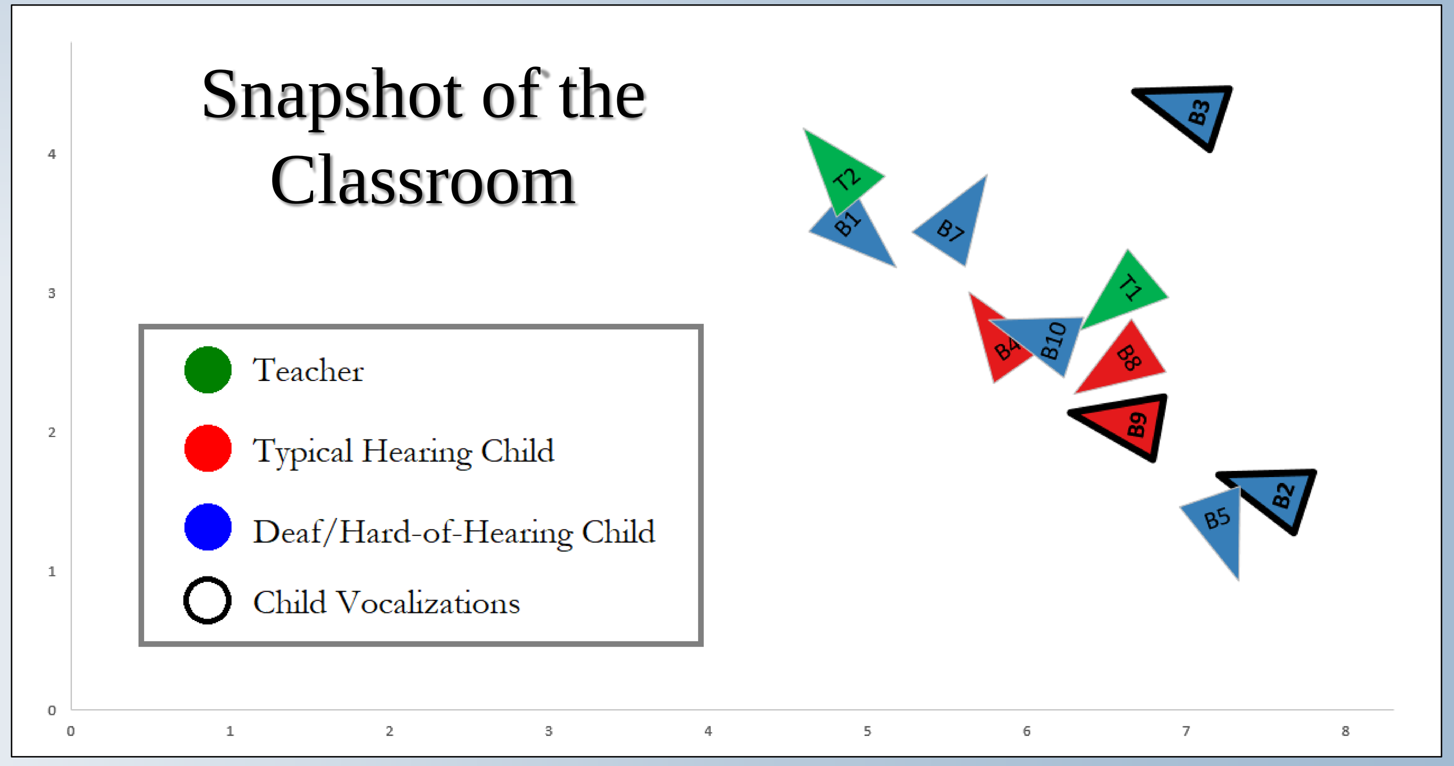



**Figure 5**: Sample snapshot taken from March 17th at 11:12:22.0 AM

## CONCLUSIONS

- The peer co-talk parameter is a simple but revealing model of interactions between children that allows us to construct networks based on peer vocal interaction.
- Aggregating and pruning network graphs by amount of contact reveals only the most significant ties between children. In figure 4, DHH child B10 is disjoint in both networks, suggesting that the subject may not have substantial social ties with other children and exhibits relatively scant language production.
- Force-directed network graphs can be valuable in visualizing a child's social centrality by using node centrality as an index. In figure 4, typical hearing child B9 tends to be central and has many meaningful ties with other subjects, notably the other typical hearing subjects B4 and B8.

## FUTURE WORK

- Construct graphs with bidirectional edges for co-talk to visualize the contribution of each individual in a pair's co-talk duration.
- Incorporate orientation data into the Matlab movies.

## ACKNOWLEDGMENTS

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