Identifying interaction groups using the Bluetooth proximity data of the conflab dataset

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BACKGROUND

- Detecting social behaviour through forming **F-Formations** from the proximity between people [1]
- **Proximity** is based on detected RSSI values [2]
- **RSSI** values are based on the Bluetooth signals detected with the "Midge"

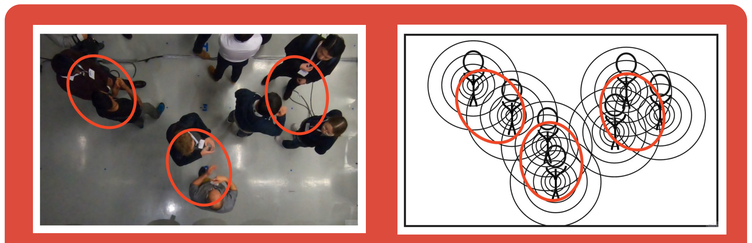

Fig 1: 3 distinct F-formations. The circles indicate the Bluetooth waves coming from the sensors.

PROBLEMS

- **Noise** through signal reflecting at walls, bypassing people, other devices, covered sensor, etc
- **Interaction** -> who is interacting with who?

NOISE FILTERS

Median filter

- Common approach
- Median shouldn't deviate so much from expected value throughout an interaction
- Allows for missing data values

Gaussian smoothing

- RSSI values are random [3]
- Probability of a certain distance between participants described by RSSI value is Gaussian distributed

Low frequency pass filter

- Gaussian filter is a specific low pass filter
- Assumption: Participants don't move to much while interaction with each other

SLIDING INTERACTION WINDOW

- Assumption: Participants interact with each other for a distinct amount of time
- Helps to discard bypassing people
- Serves as threshold for considering certain values

RELATIONSHIP BETWEEN RSSI AND PROXIMITY

- Signals are not noisy
- DIstance between subjects conducts if people form an F-Formation

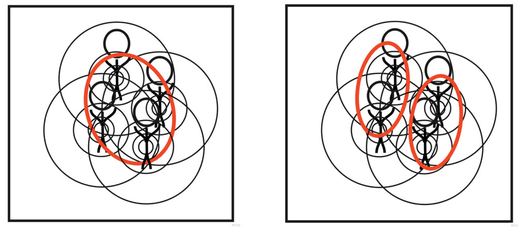

Fig 2: Two possible scenarios when a fourth person joins the interaction group in the top right of figure 1.

RESULTS

- Consulting **2/3 of a detected group** gives better results than having the whole group match the ground truth
- **Low-frequency pass filter** gives the best F1 score of **81.8 %**
  - with a cut-off frequency of 0.07 Hz and an interaction window of 20 seconds
- **Precision** scores are higher than recall
- Noise reduction only works well with the concept of an **interaction window**
- **Orientation** has a big influence on the resulting RSSI values

Precision	Recall	F1-score	Window	Kernel	Filter
0.92	0.6499	0.763	20 sec	~	No
0.91	0.69	0.788	80 sec	10	Med
0.9269	0.717	0.808	20 sec	30	Gau
Precision	**Recall**	**F1-score**	**Window**	**Cut-off**	**Filter**
0.920	0.737	**0.818**	20 sec	0.07	Low

Fig 4: Results when condcuting noise filters combined with interaction window

METHODOLOGY

Data set

- Crowded conference setting of 48 participants

Experimental Approach

- **Noise filters** in combination with **interaction window**
- Different **kernel sizes** for median filter and Gaussian smoothing
- Different **cut-off** frequencies for low pass filter
- Different **window sizes** to understand how long people interact
- **Dominant set algorithm** to find maximal cliques based on affinity between participants

Fig 3: Interaction scenario of 10 seconds to analyse the impact of proximity on RSSI

- **2 scenarios** to check the influence of proximity to RSSI
  - 1 scenario: Figure 1
  - 2 scenario: Figure 3

CONCLUSION

- Using proximity data based on RSSI values to detect F-Formations is a valid first step
- Noise filters have an effect when combined with interaction window
- Sliding window results in higher precision scores which discards rather group participants than includes false participants in a group
- Orientation has big influence on the resulting RSSI values

OUTLOOK

This research has shown that using only proximity to detect F-Formations already gives good accuracy results. Nevertheless, results have shown the urge for a combination of proximity and orientation. A possible combination could be a new equation which fills the affinity matrix which is used for the dominant set algorithm.

[1] Y. Hirabe, M. Fujimoto, Y. Arakawa, H. Suwa, and K.Yasumoto, "Effect on group detection based on human proximity for human relationship extraction in daily life," in 2017 46th International Conference on Parallel Processing Workshops (ICPPW), 2017, pp. 1-7. DOI: 10.1109/ICPPW.2017.14.
[2] S. Liu, Y. Jiang, and A. Striegel, "Face-to-face proximity estimation using bluetooth on smartphones," IEEE Transactions on Mobile Computing, vol. 13, no. 4, pp. 811-823, 2014. DOI: 10.1109/TMC.2013.4
[3] Z. Jianyong, L. Haiyong, C. Zili, and L. Zhaohui, "Rssi based bluetooth low energy indoor positioning," in 2014 International Conference on Indoor Positioning and Indoor Navigation (IPIN), 2014, pp. 526-533.DOI: 10.1109/IPIN.2014.7275525.