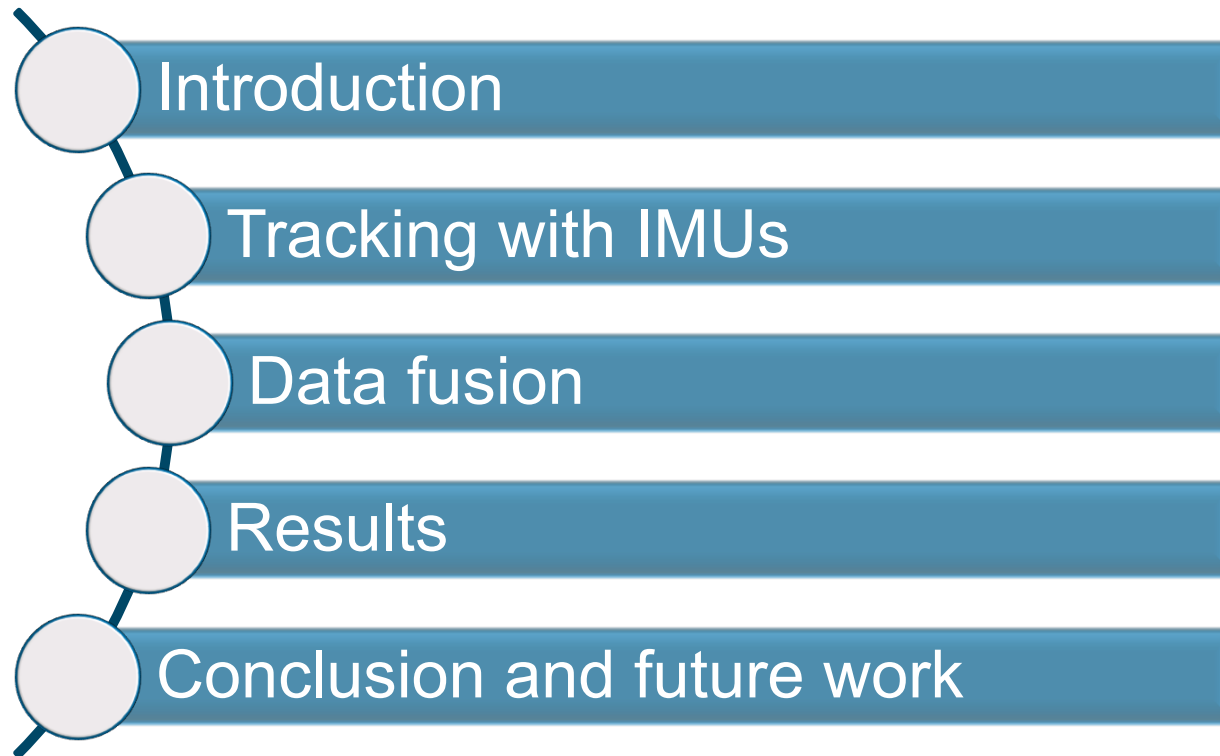


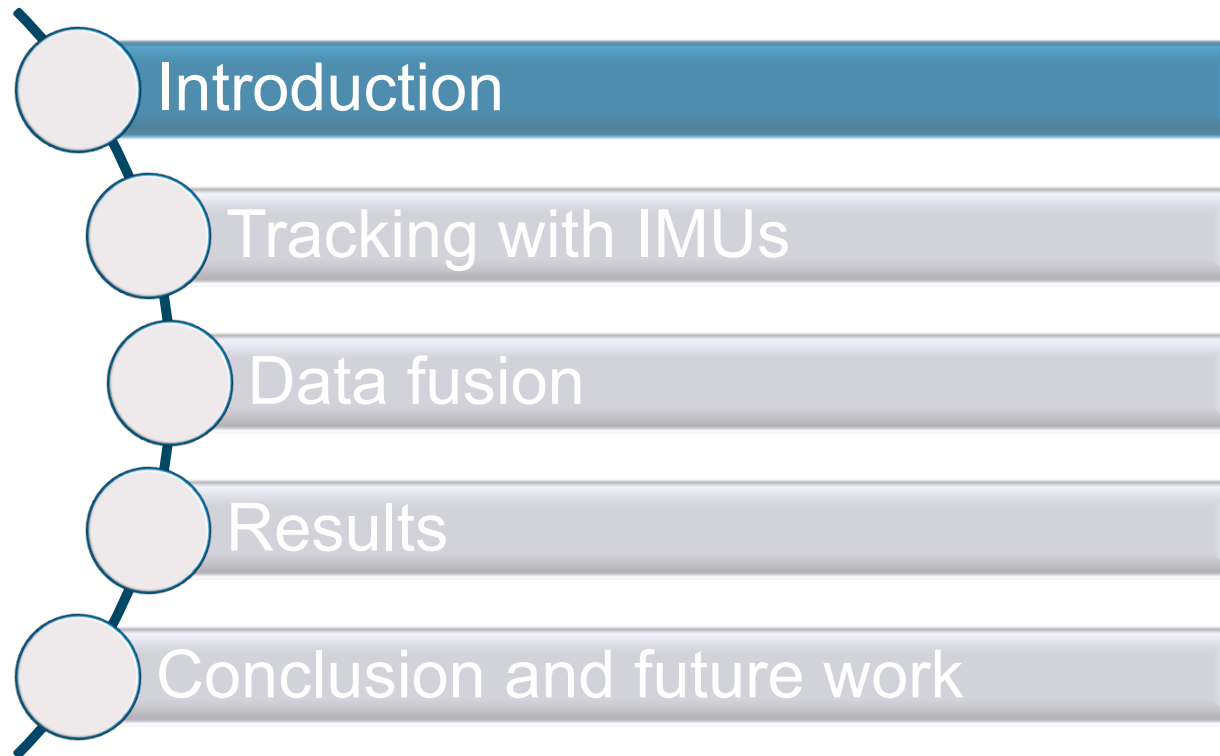
Tracking of wheelchair users in dense crowds

IPIN 2017 | September 18, 2017 | Jette Schumann

Structure



Structure



Motivation

Lack of understanding of
pedestrian dynamics



Conduction of pedestrian
experiments



Detecting trajectories



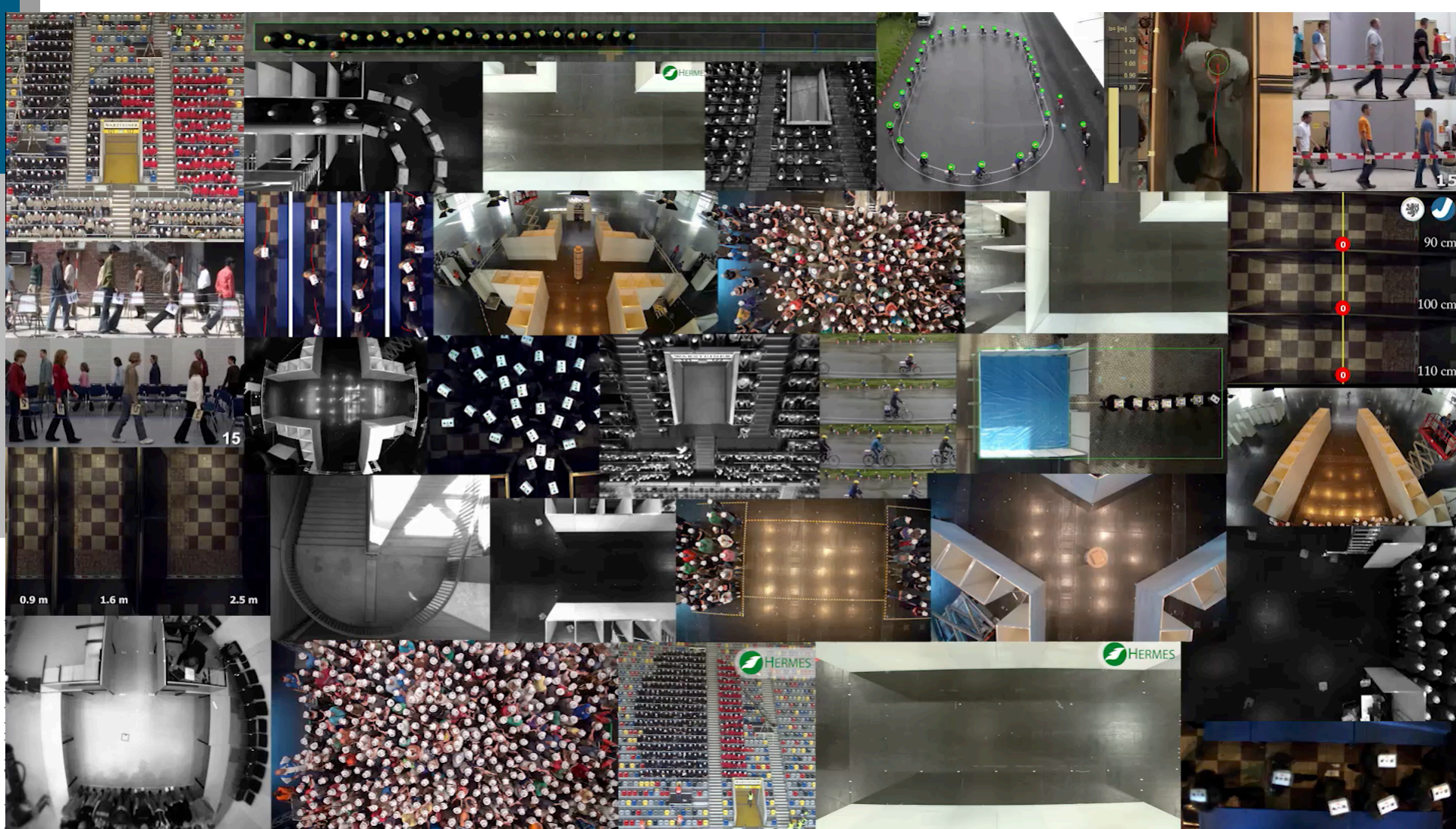
Analysis, modelling and
simulation



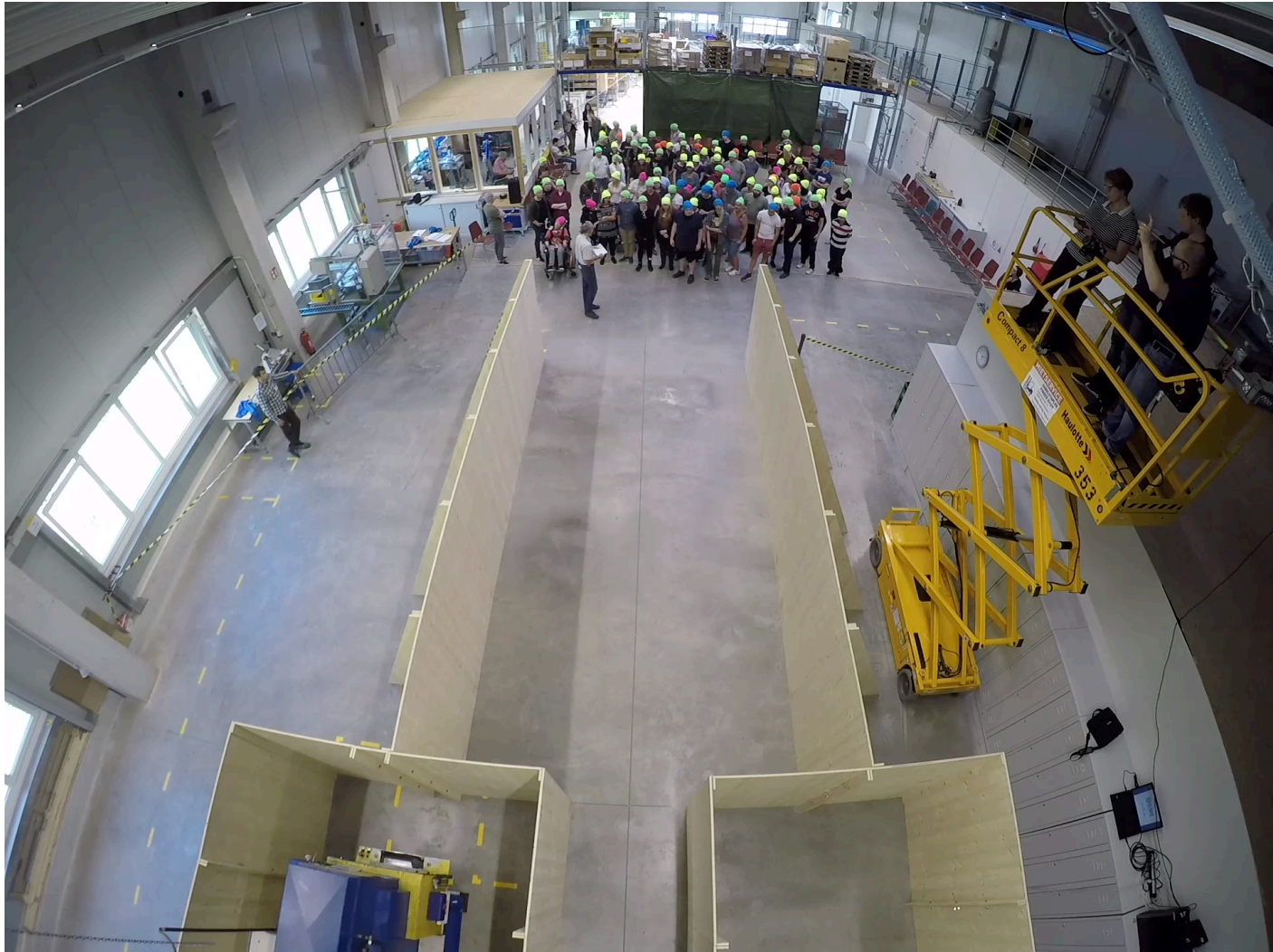
Safety



Pedestrian experiments



Latest experiments



September 18, 2017

Jette Schumann | j.schumann@fz-juelich.de

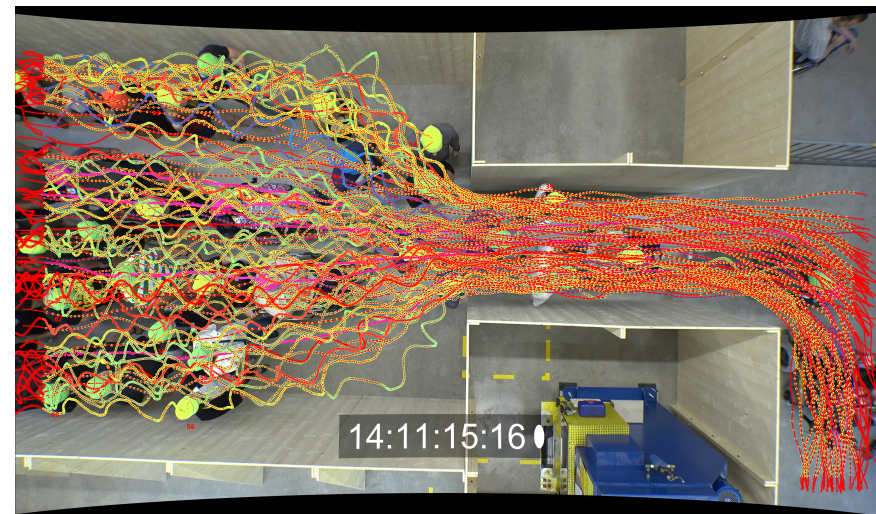
Tracking system

- **Cameras** as basic detection and tracking system
- **Caps** for heights
- Latest experiments with **heterogeneous crowds**

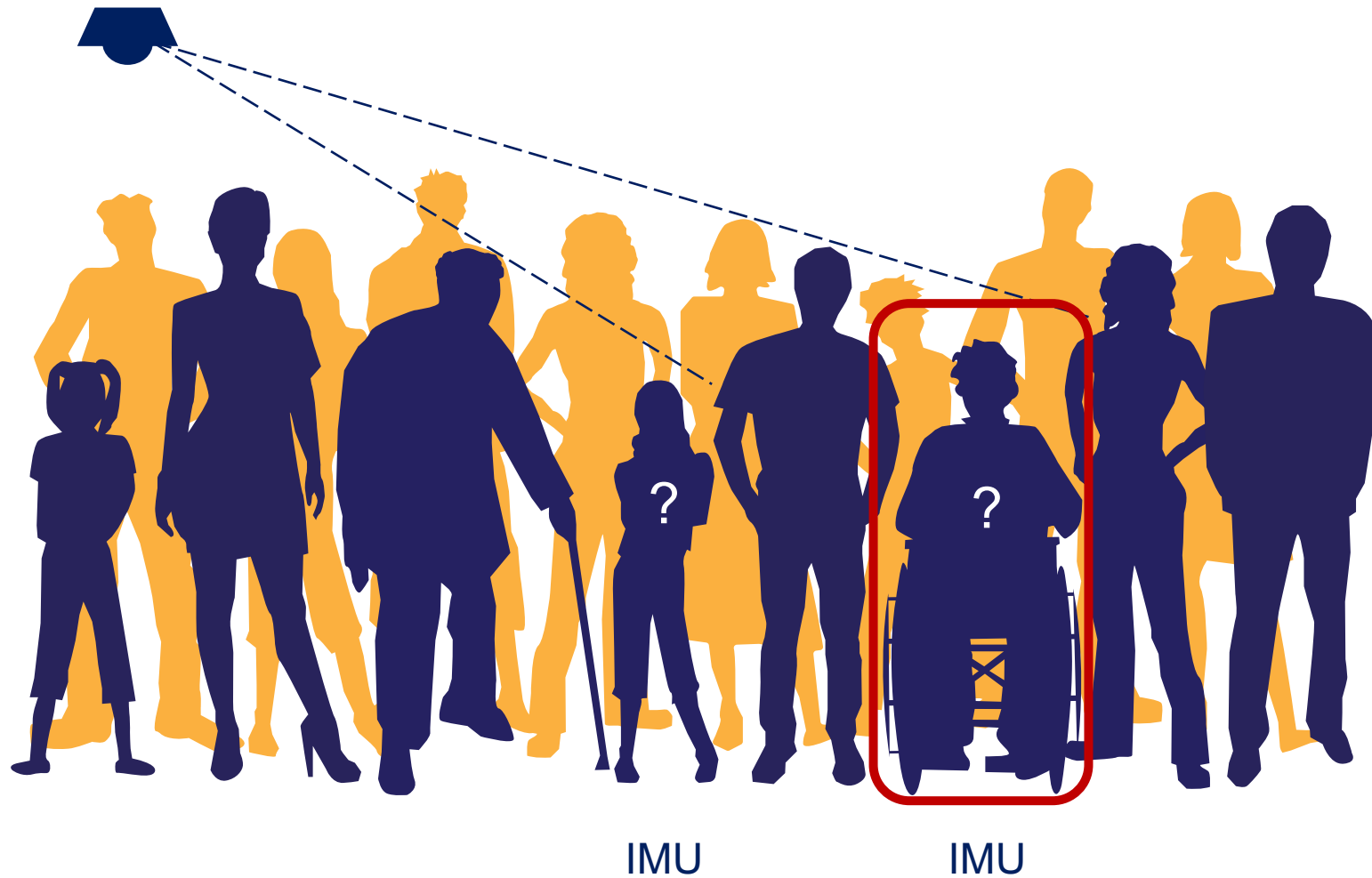


„Safety for people with physical, mental or age-related disabilities“

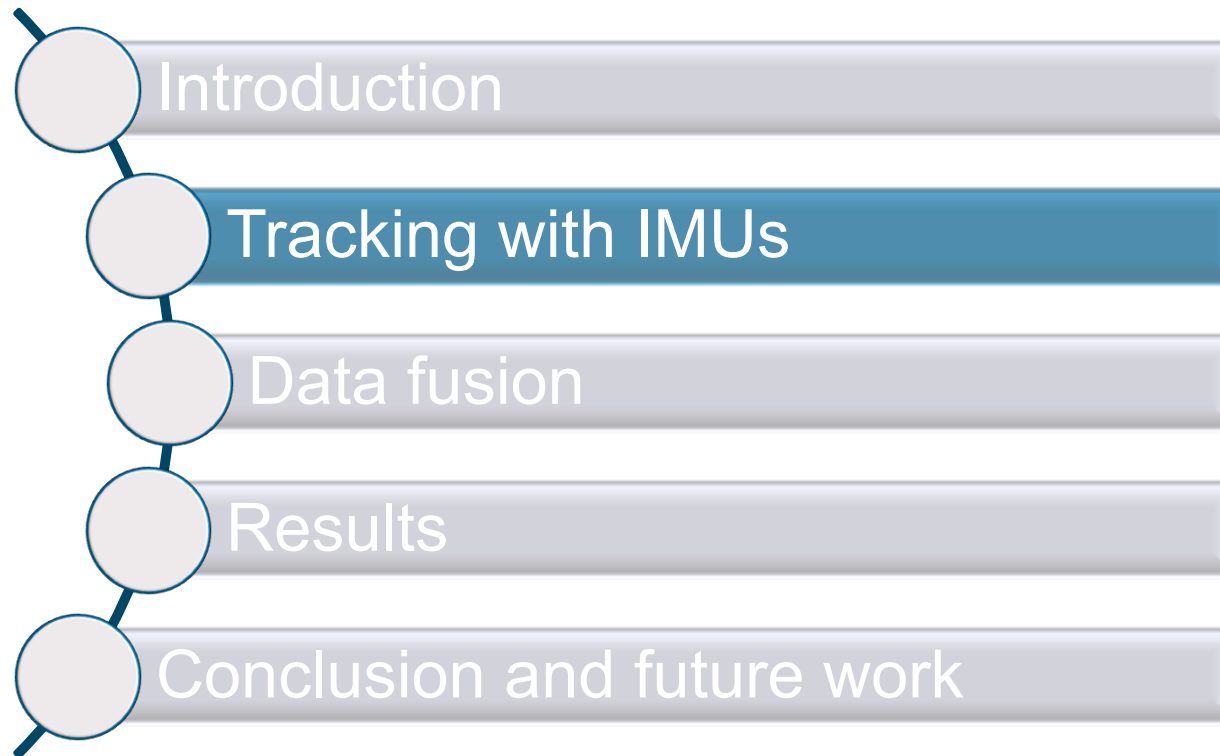
→ **New requirements**



Occlusion

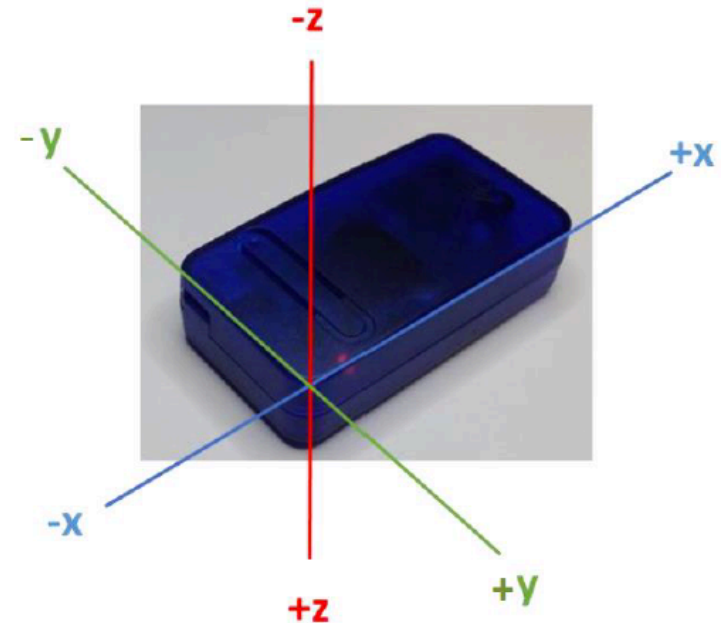


Structure



Inertial Measurement Units (IMU)

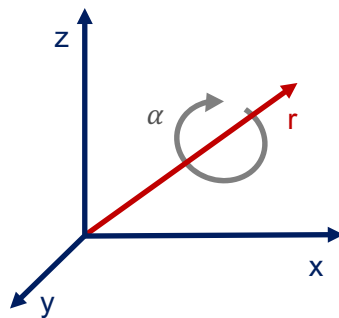
- Use IMU data to **fill gaps**
- Components:
 - Accelerometer
 - Gyroscope
 - Magnetometer
- Self-contained
- **Local storage**
- **Wireless** controlling
- **Synchronization** with camera system via LED signal



© SABEL Labs

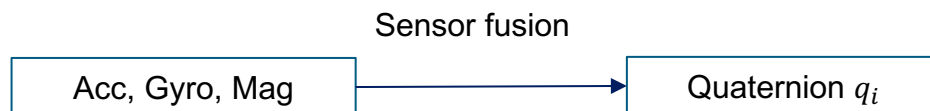
Inertial Navigation System (INS) Algorithm

1. Calculation of new orientation



2. Align acceleration data in global space

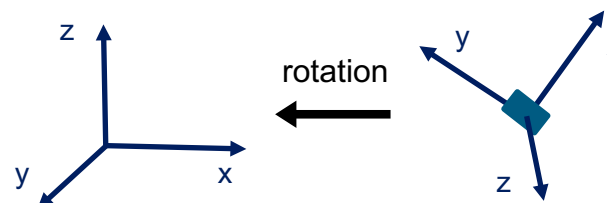
Madgwick orientation filter



$$q_i = \begin{pmatrix} \cos(\frac{\alpha}{2}) \\ -r_x \sin(\frac{\alpha}{2}) \\ -r_y \sin(\frac{\alpha}{2}) \\ -r_z \sin(\frac{\alpha}{2}) \end{pmatrix}, \text{ with rotation angle } \alpha \text{ and rotation axis } \begin{pmatrix} r_x \\ r_y \\ r_z \end{pmatrix}$$

Rotation by quaternion multiplication

$$acc_global_i = q_i \otimes acc_local_i \otimes q_i^*$$

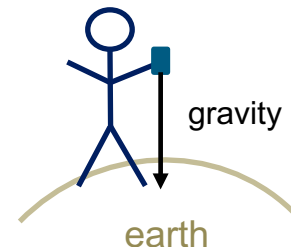


Inertial Navigation System (INS) Algorithm

3. Subtract gravity

Calculate linear acceleration

$$acc_global_linear_i = acc_global_i - \begin{pmatrix} 0 \\ 0 \\ 9.81 \end{pmatrix}$$



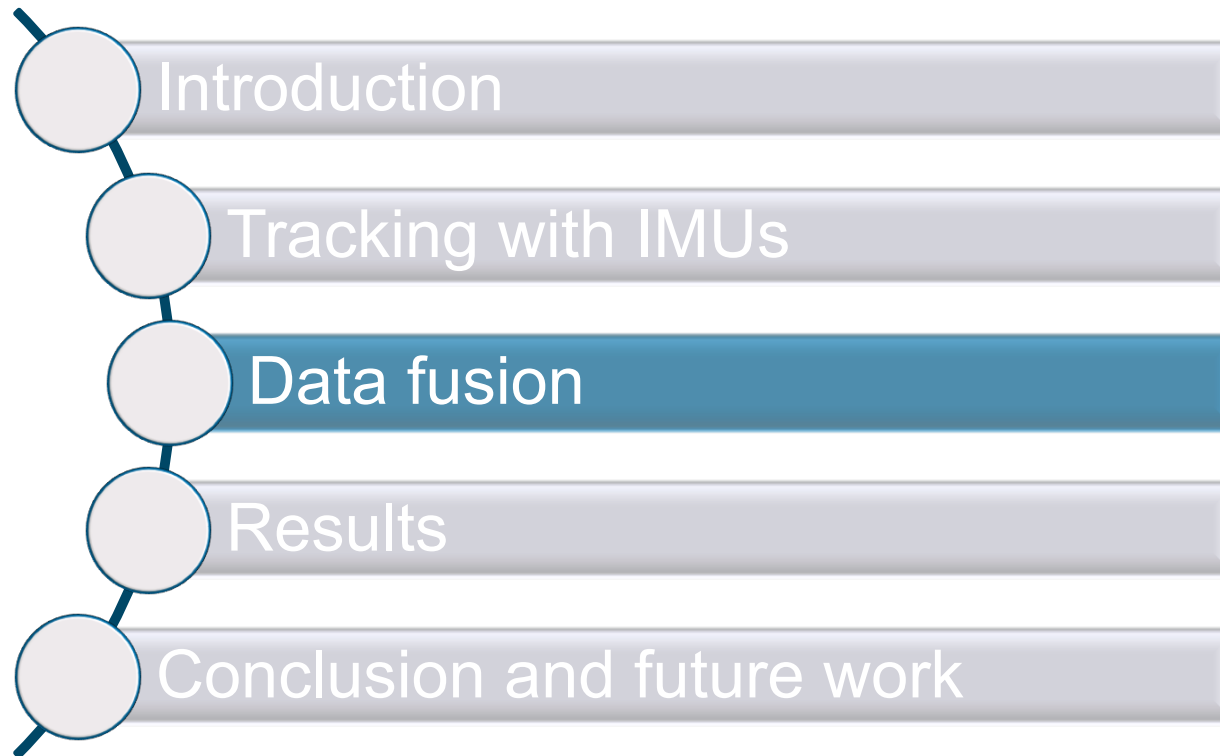
4. Double integration of acceleration

Numerical integration

$$\begin{aligned} v_i &= v_{i-1} + \Delta t * \Delta acc_global_linear_i \\ s_i &= s_{i-1} + \Delta t * \Delta v_i \end{aligned}$$

Error accumulation!

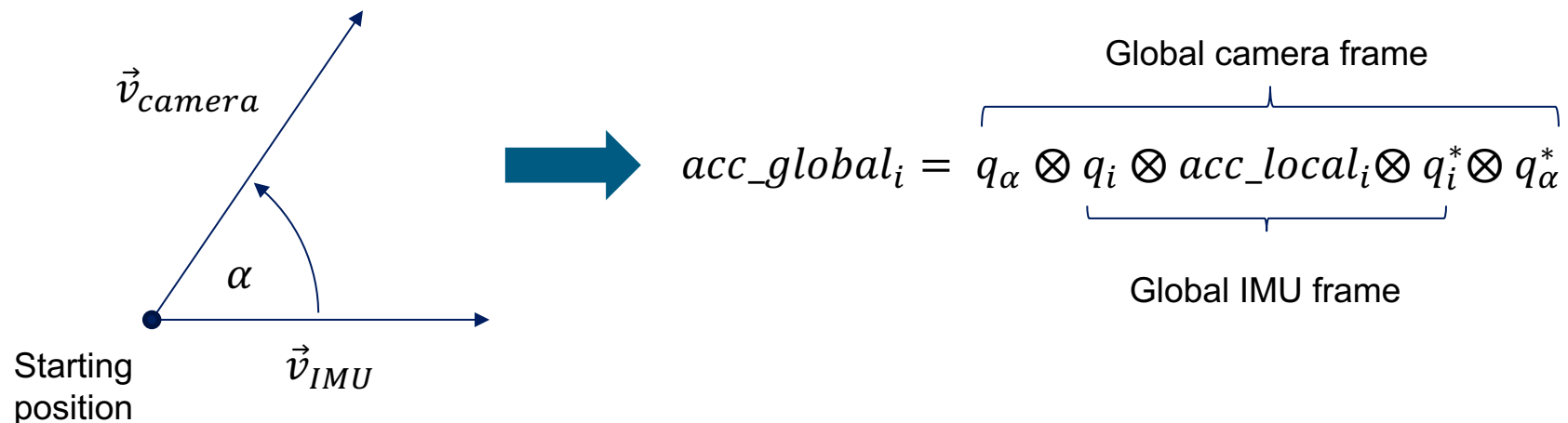
Structure



Alignment of coordinate systems

- Camera data: absolute arbitrary coordinate system
- IMU data: NED coordinate system

→ **Alignment of velocity** vectors in x-y-plane

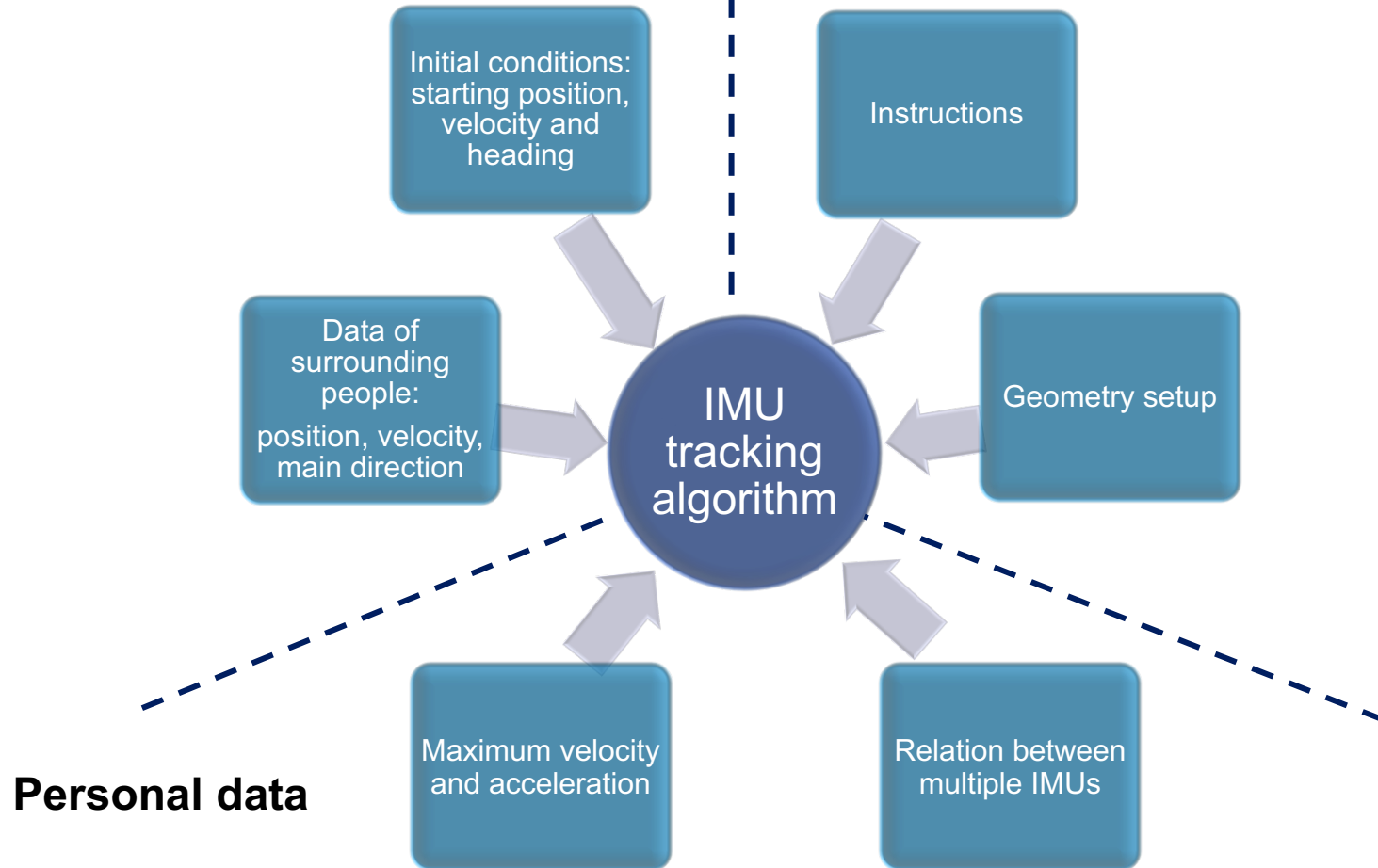


Work in progress!

Restricting the drift

Camera based data

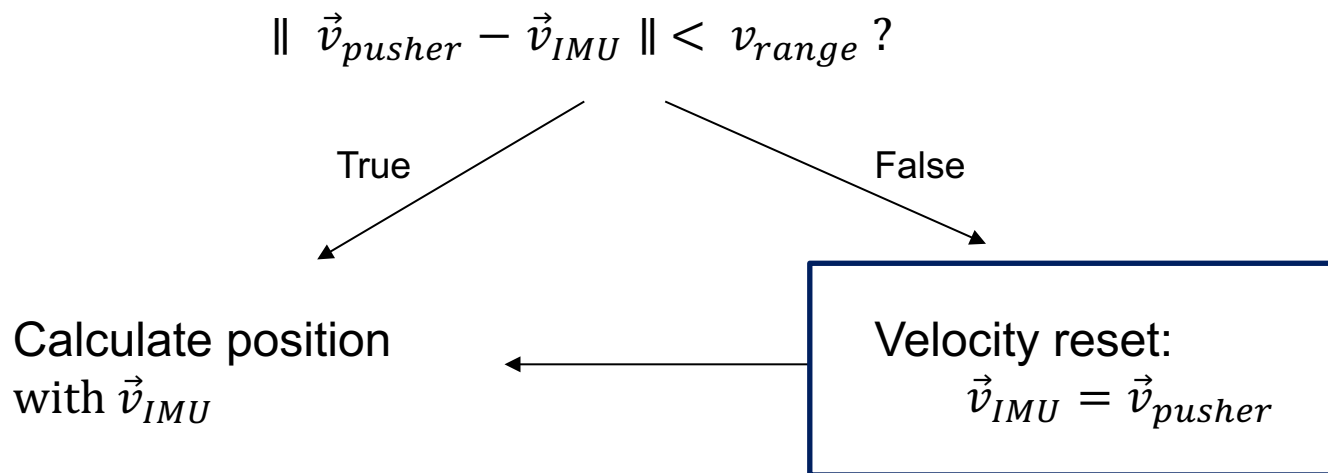
Experiment setup



Restricting the drift

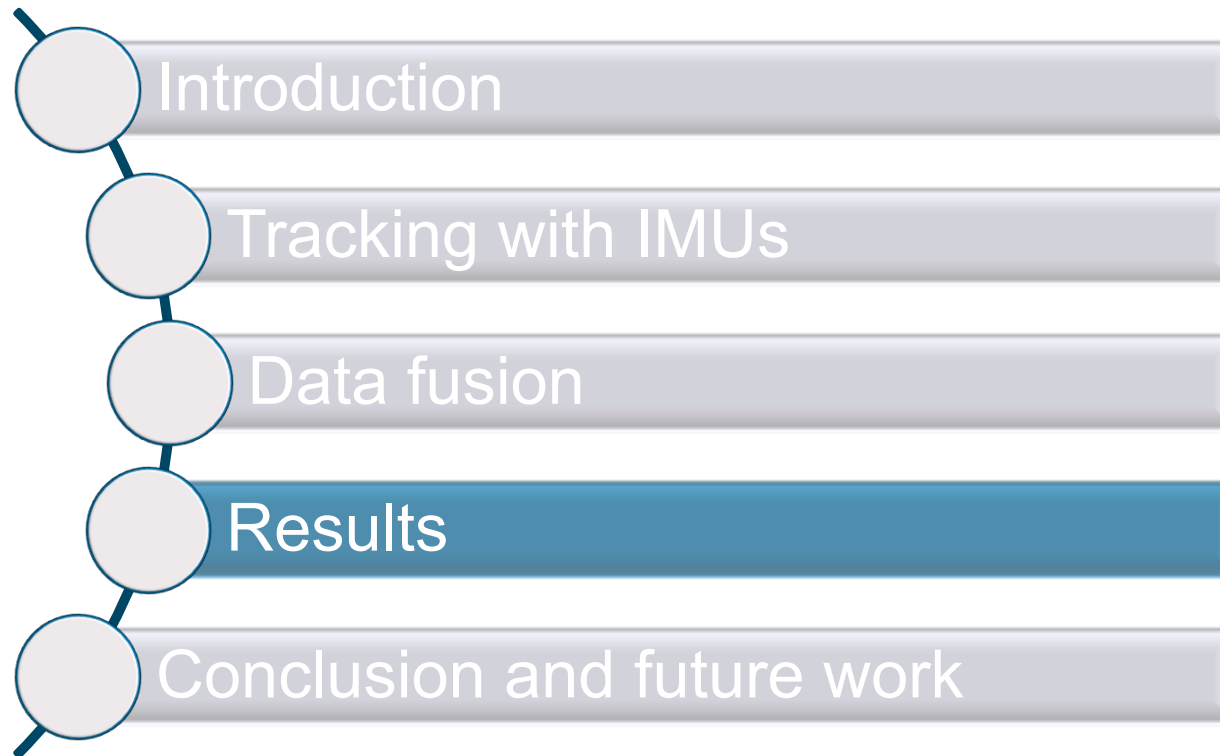
First approach

- **Restriction** of the movement of the wheelchair with the velocity of the **pushing person**



Work in progress!

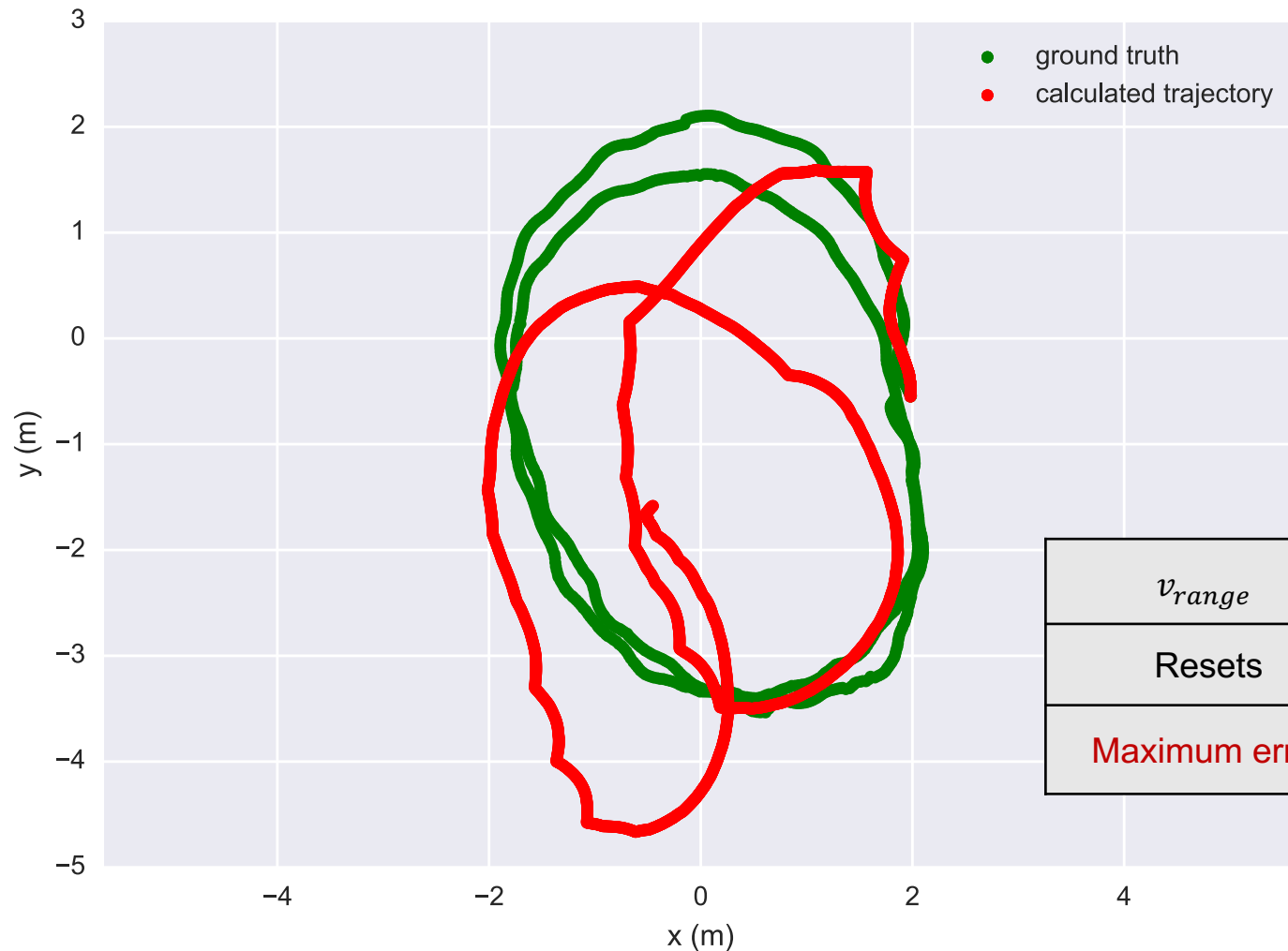
Structure



Preliminary studies

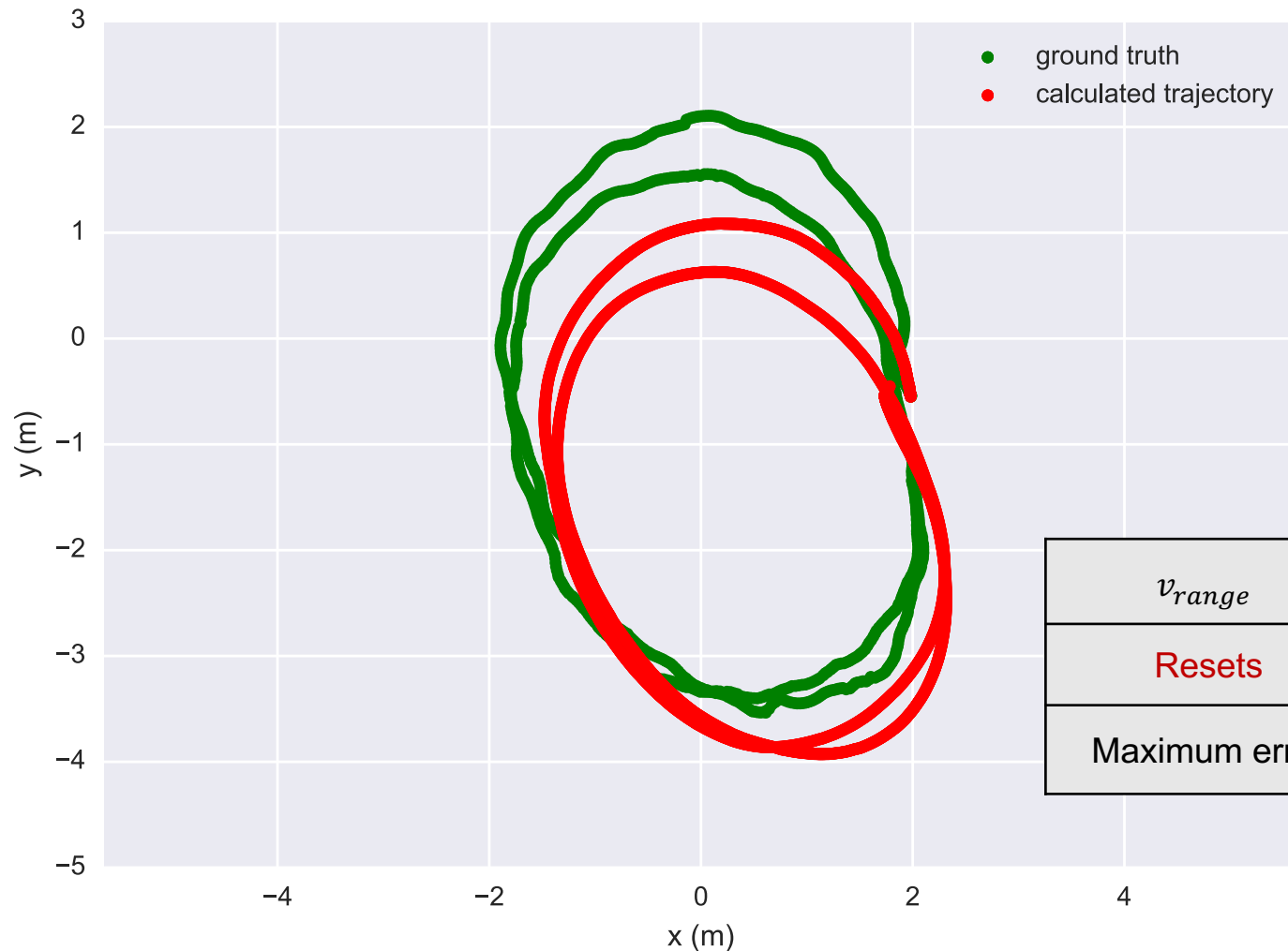


Results



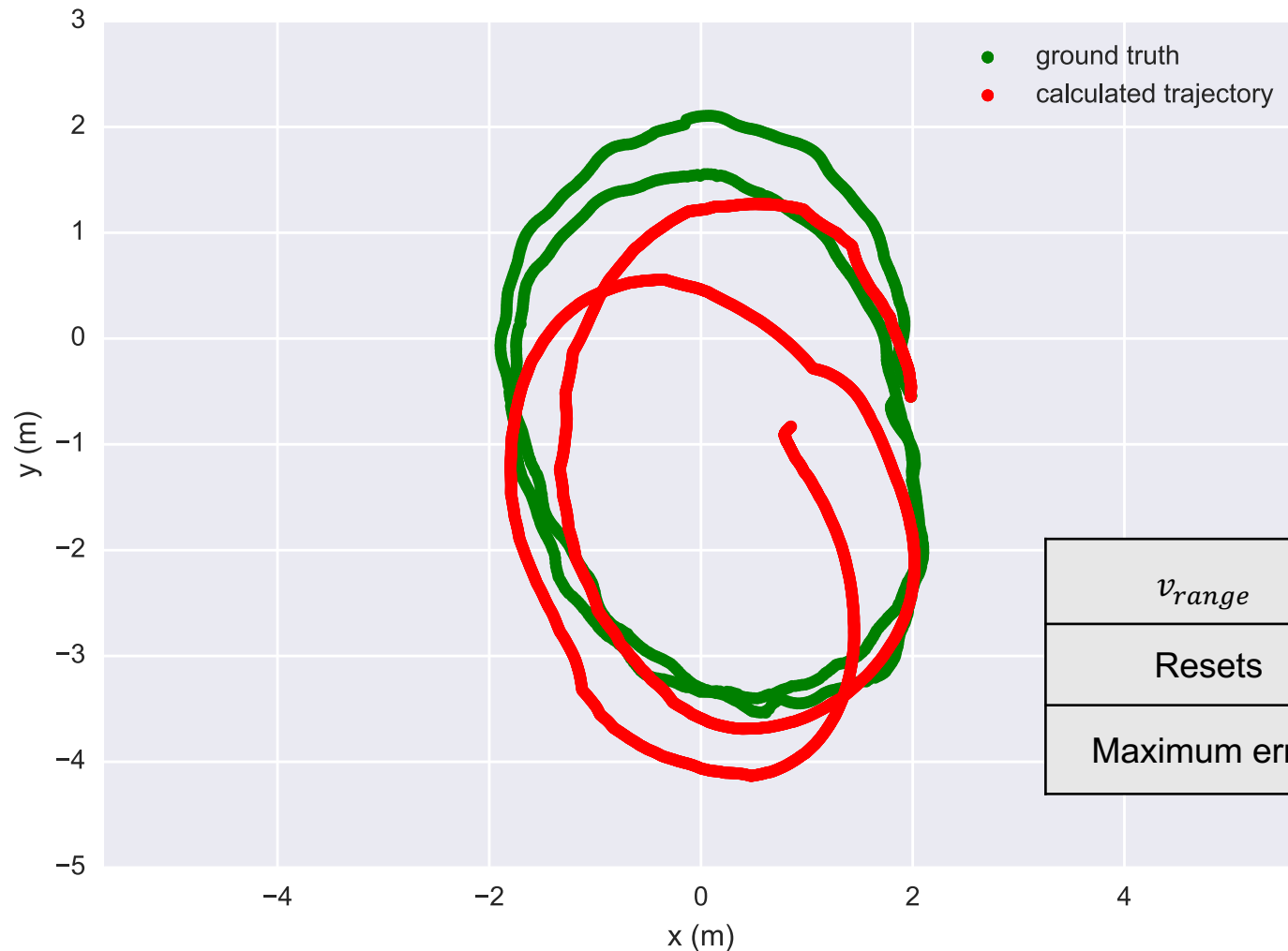
v_{range}	0.10 m/s
Resets	3.3 %
Maximum error	2.57 m

Results



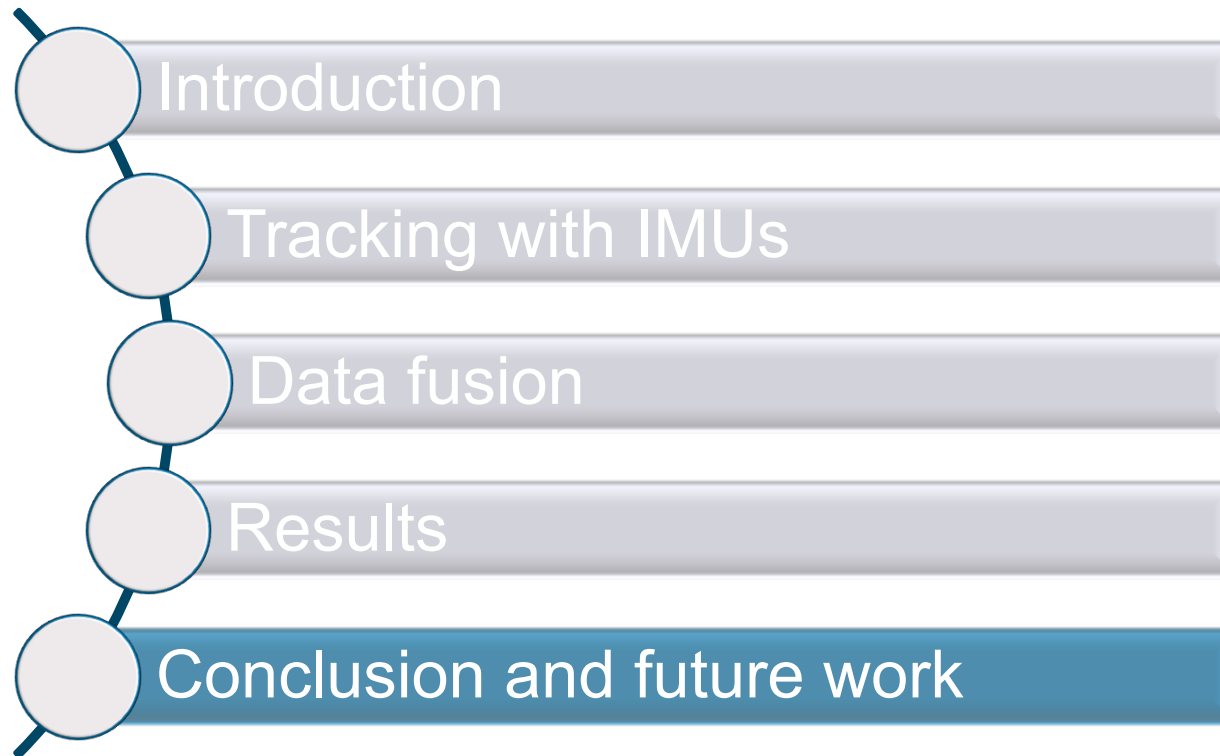
v_{range}	0.01 m/s
Resets	38.1 %
Maximum error	1.5 m

Results

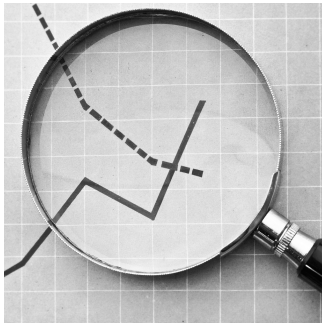


v_{range}	0.05 m/s
Resets	7.3 %
Maximum error	1.49 m

Structure



Conclusion and future work



- **Hybrid tracking system** consisting of cameras on the ceiling and IMUs attached to small pedestrians
- IMU data used to **close gaps** in trajectories
- Tracking of a wheelchair **restricted** by velocity of the pushing person



- **Data fusion:** IMU itself, IMU-IMU, IMU-camera
- **Step** and Heading System