UNIVERSITÄT ZU LÜBECK
INSTITUTE FOR ELECTRICAL ENGINEERING IN MEDICINE

Bachelors / Masters Practical Project *or* Bachelor / Masters Thesis

Visual Odometry for Autonomous Mobile Robots

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Ego motion estimation is a fundamental building block of autonomous mobile robots [SN2004]. It is essential for decision making, motion planning, and control. Over the past decade, algorithms and systems have been the subject of intensive research, with great advancements being made.

Visual odometry (VO) is one approach that has recently gained momentum [SF2011]. Its basic idea is to estimate the relative motion of an agent based on video data. The name of VO relates to conventional **odometry**, which stands for estimating the motion of a vehicle based on sensors in the robot's wheels.

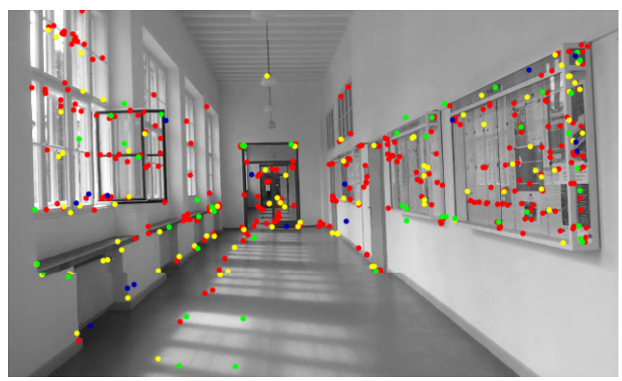

Fig. 1: Visual key points to be tracked by the algorithm (*source*: Sebastian Hilsenbeck, TU München).

Existing approaches of VO identify **visual key points** and track them over time; see Fig. 1. The motion of the agent can then be computed based on their distance. Of course, this approach does not work if the visual points are actually in motion and not fixed in the inertial system.

Nonetheless, there are several advantages of VO over other approaches for motion measurement. Unlike conventional odometry, VO is not affected by tire slip, and therefore works also on slippery surfaces and uneven terrain. Video data is available everywhere, for example also in tunnels, where GPS measurements fail. Moreover, instead of additional sensors, VO requires only video data.

Cameras are inexpensive and available in most autonomous systems anyways. Therefore VO is frequently used, in particular, for **exploration rovers** by NASA.

In this project, **different algorithms for VO** are explored and implemented. The goal is to examine and improve their accuracy and robustness in a laboratory space. The challenge is to extract the relevant information from the great amount of video data in real-time.

To this end, some of the weaknesses of VO may have to be overcome by **sensor fusion**. This means that the information of multiple sensors is combined into the best possible estimate of the robot's motion; see Fig. 2.

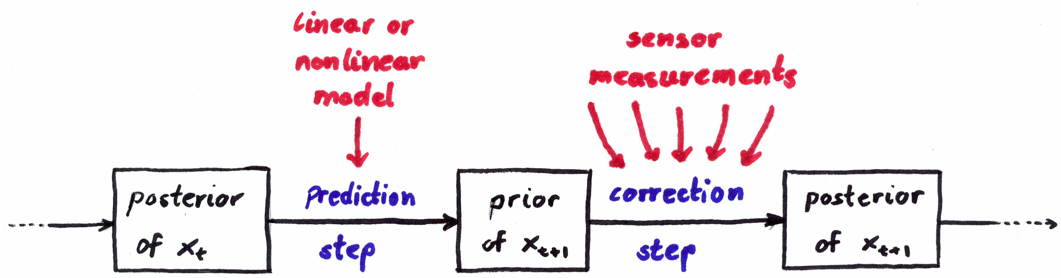

Fig. 2: Schematic representation of a Kalman filter to estimate the state x_t of an agent.

A sensor that is often used in combination with VO is an inertial measurement unit (IMU). Recursive Bayesian estimation, such as the **Kalman Filter (KF)**, is a popular approach for sensor fusion [Sim2006]. The KF can be used with linear and nonlinear models, and any observation can be used to update the current belief state of the agent.

References

[SN2004] Siegwart, R., and Nourbakhsh, I.R.: *Introduction to Autonomous Mobile Robots*. MIT Press, Cambridge (MA), 2004.

[SF2011] Scaramuzza, D., and Fraundorfer, F.: Visual Odometry. Part I: The First 30 Years and Fundamentals. *IEEE Robotics & Automation Magazine* (18), 2011, pp. 80-92.

[Sim2006] Simon, D.: *Optimal State Estimation*. John Wiley & Sons, Hoboken (NJ), 2006.