Precise localisation in the computer-aided surgery

Algorithms for the precise localisation of moving objects

1 Project goal

With computer-aided surgery, the surgeon receives constant information about where exactly the surgical instruments are, even if he cannot see them directly. An important part of such systems is the precise actual localisation of the instruments. For precise position and orientation determination, known points (so-called markers) on the instruments are measured by means of a camera system. In addition, inertial measurements of the object, such as accelerations and angular velocities, are given.

The aim of this project was to develop an algorithm which is capable to achieve a very precisely determination of the position of the surgical instruments (consisting of position and angle) for such a measuring system. A position estimate that is as precise as possible should be achieved, particularly during dynamic movements. In order to guarantee the reliability, it is necessary to recognize and compensate for noise and interference as well as to detect outliners. Furthermore, the algorithm should be optimized in a manner so that it could be reliable implemented on a microcontroller and meet the very high real-time requirements in such safety-critical medical applications following the according functional safety standards.

From the point of view of data processing, the greatest challenge in this project is that the individual points on the object are measured one after the other. As a result, the orientation of the object in space is not clear for every measurement.

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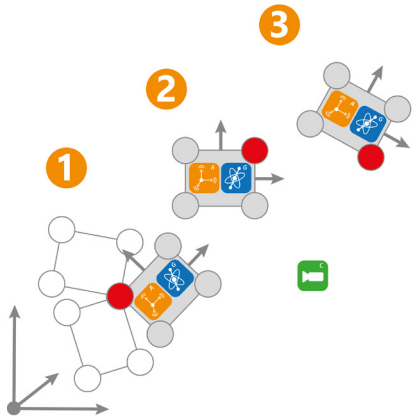
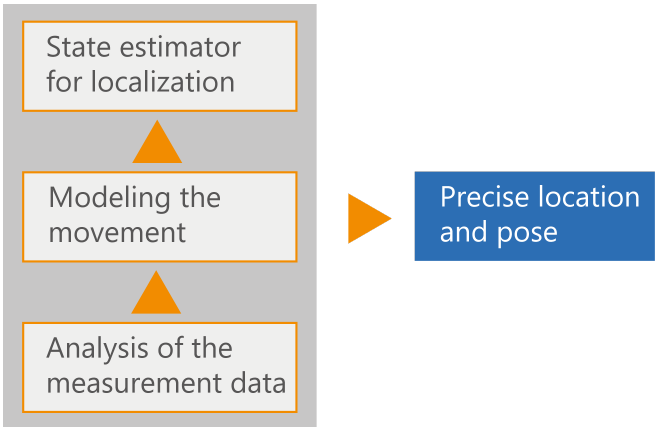
Furthermore, the object moves during the measurement and thus the measurements of all points correspond to different positions. The algorithm to be developed should, however, very precisely determine the current position of the surgical instruments for each measured value and ensure that outliers are compensated.



Measuring system for the localization of surgical instruments. Based on acceleration, yaw rate and alternating marker position, the position can be determined very precisely using intelligent algorithms.

2 Development approach

- The overall project was implemented in five sub-projects.
- Analysis of the problem and the measurement data and establishment of the mathematical model.
- Modeling the dynamic movement of the object for translation and rotation.
- Development of a state estimator for the calculation of the current situation.
- Implementation of the algorithm development in a rapid prototyping language.
- Implementation of software development in C++.



3 Result and benefit

- Calulation of the current situation in real time.
- Detection and compensation of outliers in the measurements.
- Increased robustness against partial obscuration of the object.
- Reduction of susceptibility to failure.
- Increase in the accuracy of the customer product.
- In addition, a source of interference in the hardware could be identified and eliminated, which had led to inaccuracies.

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