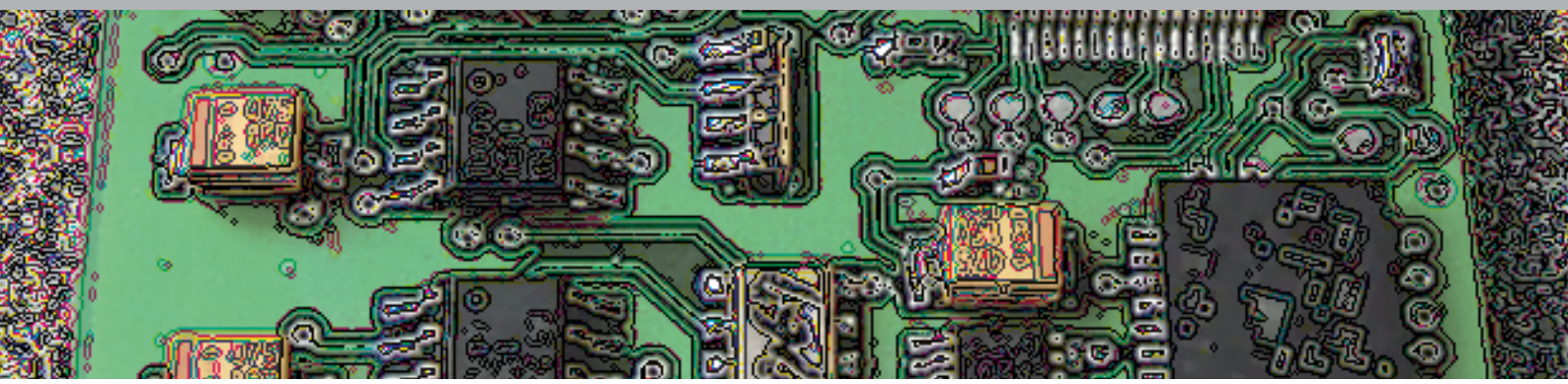
Fraunhofer
IPA

FRAUNHOFER INSTITUTE FOR MANUFACTURING ENGINEERING AND AUTOMATION IPA



SENSOR FUSION – ALGORITHMS AND SOFTWARE

Fraunhofer Institute for Manufacturing Engineering and Automation IPA

Nobelstrasse 12
70569 Stuttgart | Germany

Contact
Dipl.-Ing. Bernhard Kleiner
Phone +49 711 970-3718
bernhard.kleiner@ipa.fraunhofer.de

www.ipa.fraunhofer.de

Introduction

Sensor fusion aims to merge and combine different sensor data to acquire an overall view of a system. A characteristic of sensor fusion is the use of sensors to measure variables with different measurement methods. The calculation also serves to derive state variables, which allow for a qualitative assessment and correction of the sensor input signals. The Fraunhofer IPA provides support for all development stages, from theoretical research, modeling and design to real-time implementation and verification on the target system.

State estimation

The state of a system is described by predefined variables such as position, orientation, or velocity. Often, these variables cannot be directly measured or the measurements are prone to errors. The sensor fusion filter tries to maximize the accuracy of these variables by adding more information, while greatly minimizing, for instance, the deviations between system state and available reference and supporting signals. This makes the state estimation more robust, enabling a prediction of the state with the system dynamics model, even if the supporting or reference signal is temporarily not available.

Pattern recognition

Many applications require both the system state as defined above and the evaluation and recognition of typical signal characteristics and combined individual states. The Fraunhofer IPA has developed specific methods for pattern recognition to efficiently solve this problem. Motion patterns and other signal patterns provide additional information that cannot be obtained from sensor data alone. The individual sensor data are analyzed and evaluated to generate characteristics that allow descri-

© Fraunhofer IPA

bing the pattern. Then, these characteristics can be detected by classification algorithms and read out as discrete data sets.

Situation recognition

With respect to pattern recognition, the Fraunhofer IPA has coined the term 'situation recognition'. A situation arises from a recognized pattern, which is linked to an underlying model of the environment. The environment model is specified by existing, model-based knowledge, including boundary conditions, constraints, or transition probabilities from one situation to another. With the resulting hybrid fusion filter it is not only possible to predict the system state but also to forecast the system situation at the situation level. The acquired knowledge then allows for pro-actively adapting the system.

Software toolkit

The Fraunhofer IPA has created a platform-independent and portable software toolkit that is continuously being expanded to include new insights and methods from ongoing research work. The toolkit is designed to put the above-mentioned methods of state estimation and pattern recognition into practice. The toolkit can be used on desktop computers, embedded systems, and micro controller platforms. The following operating systems are currently supported: Linux, embedded Linux, Microsoft Windows and Android.

Interfaces and sensor connections

The software toolkit supports all sensor systems developed at the Fraunhofer IPA and can easily be adapted to customer-specific sensors. Our particular expertise lies in the design and building of multi-sensor systems combining both radio systems and cable sensors. Aspects such as the synchronization of signal sources pose a particular challenge for mixed sensor systems and have already been addressed by us for the following sensor interfaces: CAN, Ethernet, USB, UART, Firewire, CameraLink, and ZigBee.

Use cases

The presented methods and approaches have been successfully applied in a wide range of industry and research projects in the following fields and applications:

- Orientation measurement and artificial horizon
- Motion compensation and stabilization
- Navigation systems for indoor applications
- Medical gait analysis system including gait phases recognition
- Motion monitoring system and health monitoring
- Tracking of objects (e.g. operation theatre navigation) and persons
- Input devices for robotics and consumer devices
- Motion measurement for robot systems
- Medical diagnostic systems