„Embedded Machine Vision Tools and Algorithmic Cores“ eMVisTA-cores

Industrial applications usually demand for a high degree of flexibility for smart and simple configuration or re-configuration of production and inherent automation systems. Common specification issues are low prices for appropriate solutions feasible only by using cheap standard components wherever possible. This proposal aims to address these requirements by research and development for innovative design tools, models and architectures for engineering of embedded hard- and software components for machine vision a key technology for industrial automation and in-line quality control. The complexity to engineer machine vision systems origins from the necessity to incorporate a considerable amount of domain knowledge from the particular application. Successful compilation of customer needs into coherent specifications of technological components, mostly a mix of hard- and software, has to meet finally the quality characteristics and the real-time requirements for the products and the underlying production processes, simultaneously.

The objectives of the project eMVisTA-cores are to develop the next generation of vision technologies, image processing methods and tools for modelling of applications, for design of imaging systems and their implementation as inspection systems and their operation as integrated hardware/software systems embedded in intelligent assembly devices and robot end-effectors. This level of integration will allow to build cost-efficient machine vision systems providing ambient intelligence with optimal performance, high confidence, reduced time to market and faster deployment, especially evolutionary adaptation to new situations and/or reconfiguration for new tasks.

Embedded imaging (EI), frequently also referred to as “smart imaging” or “intelligent imaging”, is a combination of digital image processing with the characteristics of embedded systems as low power dissipation and small form factor of the entire system integrated e.g. into compact housings and finally referred to as “smart cameras”, “smart handling surveillance” or “embedded sensor-actuator systems”.
Key factor for the success of embedded imaging complying with high demands concerning performance and low price is enabled by implementation of low-level and medium-level image processing algorithms broken down to gate level of FPGAs or ASICs.
Typical demands for an industrial accepted relation of price to performance in automation are only feasible for an increasing number of application fields by embedded solutions providing encapsulated housings with high protection class and components of low power dissipation.

Examples of key applications for machine vision of industrial automation have to follow two trends of general importance in automation of production, especially in those countries with high labour costs:

- Reduction of production cycle time and
- Improvement of availability of machines and production equipment

targeting an overall increase of productivity.

In order to cope with these sometimes mutual conflicting goals machine vision systems have to provide:

- Recognition and tracking of moving objects and continuous determination of their position and quality as integral part of fast robots and pick and place handling equipment

- Motion estimation in image sequences, e.g. tracking of end-effectors for a continuous machine diagnosis and surveillance in fast and/or critical assembly processes measuring pose, speed and acceleration behaviour, continuously

- Identification of codes by robust and fast recognition also and especially in difficult imaging conditions (e.g. nailed codes on aluminium die casting by uncontrolled illumination, i.e. by a mix of natural and artificial light)

- Process control in particular assembly operations, e.g. either welding and/or laser cutting
- Image coding on high frame rates: automatically visual inspection with machine vision needs parallel documentation by archiving of control images, i.e. compressed image information has to be archived in real time that often exceeds video frame rate.

Usually, machine vision is only one component in an integrated sensor-based supervision of automation set-ups collecting data of several information channels and different sensor types as there are binary sensors like light barriers and proximity switches combined with sensors providing analogue information as distance or reflection sensors, pressure or flow sensors. Finally, all sensor inputs have to be aggregated into an entire picture describing particular events by features upon which classification can derive complex decisions.

Recent developments of smart cameras made clear that these cannot be commercialized as components only because end-users are in most cases unable to implement the dedicated software themselves. The exit from this situation is to sell smart imaging systems as dedicated solutions tailored to particular applications. Combining the demand of producing smart cameras in big lots to decrease the price per unit, it is necessary to provide a tool and design environment to speed up the entire design process considerably where implementation of real time critical algorithms onto dedicated hardware architectures implemented as FPGA-units. This approach needs particular attention to derive from a standard platform a huge amount of variants due to different applications and short time to market intervals at the same time.

Focus will be directed to concepts, methods and tools for embedded machine vision system design that master system's complexity by allowing cost-efficient mapping of applications like machine vision and product variants of smart combinations of sensor-processor units onto an embedded platform (smart camera); while respecting constraints in terms of resources (time, energy, memory, etc.), safety, security, and quality of service.

- Model-based design of vision system, validation and testing. The aim is to achieve interoperability at the semantic level of the vision models involved and design and configuration tools

- Particular design methods for machine vision, programming models, compilation and mapping tools for reconfigurable FPGA-based architectures are envisaged. The aim is to master the heterogeneity and facilitate the use of these architectures.

Key issues of the project subsumes:

- Component-based and modular design that allows for integration and for scalability and interoperability of heterogeneous set of sensors of different kind, including the

mixing of different communication and timing models necessary to aggregate the information flow

- eMVisTA-cores complements research on chip design including SoC (FPGA, ASICS) and SiP (smart camera), whereas here the focus is on generic system design, from the machine vision application down to the embedded platform architecture reconfigurable due to particular task demands.