Project Title:

**FPGA as image processing coprocessor with low-level image data compression and CMOS sensor to the use in the supervisory technology**

The CRAFT-project "FPGA-Imageprocessing" funded by the European Community under the ‘Competitive and Sustainable Growth’ Programme (1998-2002) was carried out in the period of June 1st, 2002 till May 31st, 2004.

Project No: CRAFT-1999-71178  Contract No: G1ST-CT-2002-50203

1. Summary

Health and security are fundamental needs of the people. The demand for electronic safety systems and video supervision technology in the most different life-areas is therefore very big and will increase in the future further.

Going out of these social interests, a new safety system has been developed in the CRAFT-Project "FPGA-Imageprocessing" by combining advanced technologies, primarily

- **FPGA- and CMOS-technology** with their strength concerning speed and flexibility, computation performance and low power demand,
- **DSP-technology**, that make possible the fast image transmission via public networks and/or more complex evaluating algorithms.

Furthermore, Bluetooth technology enables the camera to wireless transfers of the captured pictures within buildings, so there is no need to run the coaxial or data cables from monitored rooms to the monitors, located in room of security staff.

GSM technology enables the camera to wireless transfers of the captured pictures anywhere in the World, as long as they are covered with GSM telephone signal.

The created solution represents an advantageous combination of alarm system and video-supervision with moderate costs, that is the base for a multiplicity of applications in the supervision-technology. The new video-sensor module is able to execute many functions of the advanced image processing very fast and directly in the compact camera module.

The CRAFT-Project "FPGA-Imageprocessing" demonstrates the possibility to realize very effectively different supervision solutions built up on a common Hardware platform and Software development tools, through which a whole series of new marketable products can be reached.

In principle, we can assess: With the help of this innovative Video Camera System for various kinds of supervision it gets possible to raise the existing security systems on a higher standard.

All six SME-Contractors have the firm intention to exploit and market the project results.
The exploitation will be done in two ways:

- Marketing of the innovative products of the security technology developed in the project
- Using the new technology in the enterprises for the development of further own products and applications.

The project "FPGA-Imageprocessing" has effectuated, that new technologies have found entrance into a group of small European enterprises. These companies will cooperate and organise knowledge exchange to the mutual advantage also within the next years.

2. The Consortium

The consortium consisted of six SME-Contractors (N° 1 - 6) and the RTD-Performer (N° 7):

(1) IFAM Ingenieurbüro für Applikation von Mikrocomputern GmbH

established in Germany, Dalbergsweg 1, 99084 Erfurt

Dr. Manfred Conrad, Managing director
Phone/Fax: +49 361 659110 / 6462139
E-Mail: ifam@ifam-erfurt.de
Homepage: www.ifam-erfurt.de

Automatic dialling alarm systems, intruder systems, fire alarm terminals, synoptic tables, fire brigade control and indicator panels, fire brigade information and operation panels

(2) Hertek Care bv

established in The Netherlands, Copernicusstraat 8, 6003 DE Weert

Marcel Hermkens, Managing director
Phone/Fax: +31 495 584111 / 584333
E-Mail: hertek@hertek.nl
Homepage: www.hertek.nl

Care and emergency call systems
Fire panels, synoptic tables, fire alarm terminals

(3) EUROALARM spol. s.r.o.

established in Czech Republic, Hlavni 4, 14100 Praha 4 – Sporilov

Ales Matejicek, Managing director
Phone/Fax: +420 2 72770148 / 72770149
Mail: euroalarm@euroalarm.cz
Homepage: www.euroalarm.cz

The company provides low-cost, high-performance systems for a range of market applications in security and fire detection.

(4) NAVEUROPA DE CONSTRUCCIONES, S.L.

established in Spain, Calle Federico Garcia Lorca 16, 41800 Sanlucar La Mayor

Eduardo Macias Ortega, Managing director
Phone/Fax: +420 2 72770148 / 72770149
E-Mail: naveuropa@teleline.es

The enterprise is nation-widely working in the field of road construction and civil engineering as well as building and bridge construction.
(5) VARINEX Informatics Inc.

established in Hungary, Köszeg u. 4., 1141 Budapest

George Falk, Managing director
Phone/Fax: +36 1 2733400 / 2733411
E-Mail: falk@varinex.hu
Homepage: www.varinex.hu

Specialist in CAD and GIS (Geographical Information Systems), special application-software and Rapid Prototyping

(6) ZAMIR RECOGNITION SYSTEMS LTD

established in Israel, Manachat Technology Park, Building 1, 96951 Jerusalem

Seth Jacobson, Managing director
Phone/Fax: +972 2 6797460 / 6797470
E-Mail: seth@zamir.co.il
Homepage: www.zamir.co.il

Full-service provider of modular LPR vehicle identification solutions to both OEMs and systems integrators

(LPR = License Plate Recognition)

(7) CE-SYS GmbH Ilmenau

established in Germany, Am Hammergrund 1, 98693 Ilmenau

Dr. Ralf Mikolaschek, Managing director
Phone/Fax: +49 3677 6479 0 / 6479 99
E-Mail: r.mikolaschek@ce-sys-ilmenau.de
Homepage: www.ce-sys-ilmenau.de

Electronics development (image processing and measurement systems); EMC test centre; Computer and communication technology

3. The Technical Solution

The project concept based on developing a uniform hard and software development environment for very different image processing tasks.

It was intention of the project “FPGA-Imageprocessing” to demonstrate, that the SMEs are enabled to develop own video supervision solutions with such a Basic System, consisting on a common Hardware platform and a Software development toolkit, without large special knowledge regarding programming of FPGAs, DSPs or programming languages.

To this the RTD cooperation was organized according to the characteristics of the CRAFT programme:

- The RTD subcontract performances to the creation of a Basic System with FPGA technology that served as basis for the development of specific solutions in the participating SMEs and
- The development work of the 6 SME-Contractors, that was directed on application solutions for different use-areas of the security- and supervision-technology including additional modules for the extension of the Basic System in keeping of the solution requirements.
The following figure shows the connection between the project main emphasises as overview:

![Diagram showing connections between different components and systems]

The most image processing-systems applied until now are either PC-based or use digital signal-processors as basis for the implementation of the image processing algorithms. As opposed to this, reconfigurable, parallel computing on the image processing board, based on the FPGA, was used in our project to meet high performance requirements. This approach combined the performance of special acceleration hardware with the flexibility of programmable components.

Within the project work the RTD-Performer delivered optimised IP-cores, graphical development tools, the basic hardware platform, hardware-test tools and the design-flow for the six SME-Contractors. Thereby, these project partners were put into the position to develop own video supervision solutions based on this uniform platform without special knowledge regarding programming of FPGAs, DSPs or programming languages.
So the SMEs have created six application solutions on the areas
- Event (burglar) detection and alarm system,
- Video fire detection system for smoke, heat, beam of flame detection,
- Surveillance of patients in clinics and hospitals,
- Identification of motor vehicles and access control for special security areas,
- Supervision of buildings and bridges, securing the objects and building sites,
- Monitoring of special industrial production lines (Rapid Prototyping Machines) with fault detection and alarm.

Beyond this, the SMEs have developed a large number of additional modules within the project, which could be used for the realisation of the single applications when required.

4. The Project Results

Main results of the project are:

Development of the complete FPGA-Hard- and Software as “Basic System” including a Software development toolbox by the RTD-Performers

**FPGA-Imageprocessing in a small camera module with:**

- Powerful basic circuit board with different assembly
- Efficient programmable platform with advanced FPGAs
  - XILINX Spartan-IIIE with 300...600k system gates
  - XILINX Coolrunner II CPLD
  - AMD Mirrorbit Flash
  - different possible CMOS image sensors (color or b/w)
  - SRAM with 0...36 MBit
- Space saving design (65 mm x 100 mm) and a variety of interfaces

The prototype of the camera unit:
The SME Toolbox of modules:
The SME Toolbox contains a lot of universal Software modules for fast FPGA functions provided by the RTD-Performer for the different SME application solutions. The Toolbox was sorted in directories and in documentation as follows:

- Mathematical basic functions
- Image windows
- Transformation and compression
- Display
- Image processing basic logic functions
- Data management
- Signal generation
- Edge detection and filters
- Statistics
- Interface control
- Other image processing functions

Design flow, programming tools and software support for the realisation of the SME application solutions
The scheme of the SME Design flow is shown in this figure:

Result, knowledge and technology transfer from the RTD-Performer to the SME-Contractors (also between the SMEs)
The project success - how generally characteristically for CRAFT projects - depended quite particularly on a successful technology transfer between technology suppliers and the contracting parties according to the technology need of these enterprises.
This applied to our project:
By means of Technology and Knowledge transfer and training, the partners had to be enabled to use efficiently the FPGA technology including the development tools connected with that for the creation of own application solutions in the field of the video supervision and security engineering.
A second part of the Technology transfer covered quite special technology offers by single project partners to the project consortium, like CMOS sensor technology, GSM and Bluetooth technology, DSP technology and Embedded Systems.

The Technical Workshop (One-week Training course) in June 2003 at the RTD-Performer CE-SYS in Ilmenau was a particularly effective form of the knowledge transfer.

**Development of the CMOS Image Sensor (CIS) and additional modules by the six SME-Contractors**

The following modules have been developed by the SME-Contractors:
- CMOS Image Sensor (CIS)-modules, color and b/w
- DSP module
- Bluetooth module
- GSM module
- RS485 module
- Embedded PC module
- Housing

Prototypes able to work exist of all these modules. The dimensions and interfaces of the modules were coordinated with the RTD-Performer CE-SYS so that the assembly of compact camera units can be carried out in a uniform housing.

The modules of the SMEs together with the FPGA Basic System developed by CE-SYS have been given into a device pool, which was and is also after project end the common platform for the realization of the different application solutions of the SME-Contractors.

**Development of six different applications solutions on the base of the common developed Hard- and Software by the SME-Contractors**

Prototype solutions have been carried out successfully according to the project aims in all six SMEs at the project end.

The solutions were convincingly demonstrated by the partners in Erfurt on the occasion of the Final Project Review on 2004-06-22:

- The application solution of EUROALARM is concentrated on the Video fire detection (VFD)-system for smoke, heat, beam of flame detection.
  Target areas of the developed solution are the fire detection in Refineries, near Oil tanks, in electrical transformer stations, offshore oil platforms, traffic tunnels, etc. but also in smaller fire endangered industrial plants, public and private areas

- The surveillance of patients in clinics, hospitals, psychiatry, etc. is the intention of the Hertek application solution.
  Starting point of the application development was the problem in the hospitals:
  - Coma patient wakes up
  - Epilepsy patient has a fit
  Nobody recognizes the critical moments.

The solution demonstrated by Hertek in the Final Project Review:

The new camera captures and stores continuously pictures of the patient. If any movement is detected by the camera the doctor can watch this moment after taking care of the patient. So the patient is observed even in the critical time of awakening.
The IFAM application solution contents an event (burglar) detection and alarm system with remote monitoring for buildings, rooms, objects of all kinds. The special topic is the alarm verification. The principle of the demonstrated room surveillance is as follows:

- PIR (passive infra red) detector for motion detection
- Automatic alarm and dialing device gets alarm from PIR.
- Regarding its own programming the camera will be triggered.
- Camera stores pre and post event pictures.
- Automatic alarm and dialing device take a call to the management software.
- The Management software download the alarm pictures.
- User gets a message from the management software and can verify the event.

NAVEUROPA presented the new application solution for the supervision of buildings and bridges, object safeguarding and securing of building sites. The following principle has been realized:

- All endangered areas will be monitored by a camera.
- One camera can monitor up to 15 different areas.
- Every captured picture will be compared with stored reference pictures.
- If the camera detects any differences the pictures will be sent via GSM or Ethernet for verification.

VARINEX has developed an application solution for the monitoring of special industrial production lines (Rapid Prototyping Machines) with fault detection and interrupt alarm within our CRAFT project. The enterprise must solve the so-called „Unattended Operation Day and Night“ of their Laminated Object Manufacturing (LOM)-machines with 3D printer on a higher and more sophisticated safe way. The solution:

The main functions of the camera are image capturing, motion detection, image compression, MMS generation, and MMS sending. The motion detection is carried out by means of a supervised image window and comparison of the stored previous image with the current one. In case of image differences a motion is detected. The camera is arranged outside the LOM-machine – 3D printer and connected to the GSM network via an external antenna. The MMS image transmission to a cellular phone is a highlight of this VARINEX application solution.

The enterprise Zamir is developing new solutions for the License Plate Recognition, e.g. regarding revenue parking, access control, vehicle security, homeland security, toll roads, stolen vehicle identification, etc. The technical challenges are caused above all in the existing wide range of Plate types with different size, reflectivity, syntax, font, color, and furthermore in diverse lighting conditions, different distances, different speeds, and extent of triggering information. Zamir strives after the fulfillment of a All-in-One LPR Processing Strategy. Such processing steps like image capture, recognition and detection shall be realized within the camera unit. With the CRAFT-project results, important improvements could be reached here:

Integration of computer power into the camera and illumination components, and with it
- Increase application domain
- Increase types of plates handled
- Increase range of distance, width of field, and lighting conditions
- Reduce infrastructure requirements
- Reduce cost of installation and maintenance
We can say summarizing:
All six SME-Contractors have proved with the impressive demonstration of their application solutions at the end of our CRAFT-project, that innovative solutions have been reached in very different fields of the supervision and security engineering, based on the FPGA Basic System provided by the RTD-Performer and the common Hardware platform of the SMEs. Therefore, we have now a very good basis for the transportation of the project results into marketable products.
Furthermore, the developed Basic System and the variety of extension modules give us the possibility to create new applications again and again, also with new FPGAs.

5. To the Importance of the Project

The technology transfer has played the decisive role in the project. Advanced technologies as microelectronics and programmable logic devices, image processing, digital technology, remote communications and fast data transmission (wireless and wired) have been made accessible together to SMEs of different branches by this project. By "upgrading" of available own products and above all by product innovations, new business fields and market extensions can be obtained, which are the basis for future economic growth.

All project partners without exception have obliged themselves to disseminate and concretely exploit the project results as described in the Technological Implementation Plan. The expected project results should be realised above all in marketable video supervision systems but also for solving supervision problems in the own enterprise.

The partners intend to organise a Europe-wide dissemination process together with local multipliers which is aimed at both, potential industrial target groups and potential users of the new video supervision technology in different social areas. On this way the partners will contribute to the stronger extension of efficient supervision and security technology solutions in Europe as a base for

- Strengthening the competitiveness, ensuring the existing and creating new jobs in the involved enterprises and with further co-operative partners, like manufacturers, installers, distributors, project engineers of supervision and security engineering;
- Increasing the technological standard, innovative power and economic growth in the security industry;
- Supporting the policy for ensuring the quality of life in Europe by means of product innovations for health service, protection of the people and their property, protection in front of terrorist attacks and acts of sabotage;
- Environment saving by innovative solutions for economical working with resources, especially quality assurance and avoiding production disturbances.

6. Experiences and Conclusions

This project “FPGA-Imageprocessing" would not have been possible without the financial support and guidance provided by the European Commission.
From the experience of our project execution we can confirm: The COOPERATIVE RESEARCH (CRAFT) is a programme type which offers good possibilities for the participation of smaller enterprises in the European research cooperation, too. Therefore, it is a good thing, that the 6. Research Framework Programme of the EC contains CRAFT again. Interested enterprises should include sufficient time in their plans, though. After all, we have already started with our project preparation in the year 1999, funded with the Exploratory Award by the EC. (Unfortunately, this funding isn't possible any more.)
The CRAFT-project necessitates a considerable management and coordination expenditure. All contracting parties of our project including the project coordinator IFAM are small enterprises. Therefore, it was an indispensable support, that special parts of the administrative co-ordination are given as subcontract to an external service provider, an experienced project management company.

The project consortium can in evaluation of the Final Project Review with the demonstration of the application solutions by the SME-Contractors state unanimously, that the scientific technical project goals have been accomplished. With this positive project outcome the following conclusions were primarily connected:

(1) In view of the rapid speed of the worldwide scientific technical development it must be the main task of the project partners now, the results of the project to form to marketable products and to organize their marketing concentrated and as quick as possible. Every delay in this process means economic losses for the enterprises in the end.

(2) With the process of the transportation of the new camera system in the production is absolutely to give increased attention to the question of the legal protection of the project results by all SME-Contractors. The protection of Intellectual Property Rights should be primarily concentrated on the main emphasises of the SMEs’ application dependent development after project end.

(3) Thanks to the modular concept of the project solutions a wide range of applications (security systems, home application, industrial supervision and control) can be covered with different solutions. Market investigations of the partners have recognized that there are good marketing opportunities for the application solutions developed in the CRAFT-project. Based on the knowledge of the participation in international fairs 2003 and 2004, some colleagues stress the growing demand for Intelligent Image Sensors and Networking.

(4) The most project partners endeavour to develop further application fields, therefore. Connected with the opening up of new application fields, it is necessary to work on the further development of the project results by use of the advantages of the scientific technical progress in electronics and microelectronics with such trends, like
  – the further miniaturization of the components (FPGAs, DSPs, CMOS sensors, etc.) with an increasing capability and
  – the expected price recession at today usual electronic components.

(5) A good teamwork has developed within the project-consortium. Simultaneously with the continuous work-contacts, bilateral relationships have been formed for co-operations between partners as well as within as also outside the project work. This development had an beneficial effect for the achievement of the project objectives. The approved good cooperation shall at least partially be kept also after project end for the production of the camera systems, their marketing and distribution, the product care and maintenance as well as the further scientific technical development to the mutual advantage.

Additional Information

The primary contact for the project “FPGA-Imageprocessing” is:

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