Review of Luděk Bryan's Ph.D. Thesis

Title of the Ph.D. Thesis: Hardware-Based Object Detection Method

The Ph.D. Thesis is written in the English language, therefore my review document is also written in the English language.

a/ The current state of the art in the field relevant to the Thesis

The topics addressed in the Thesis: hardware solution of objects detection techniques, embedded systems and their applications in computer vision belong to one of present-day directions of using electronic systems design. Computer vision and techniques for its support in different applications are mostly implemented by software products and currently they are well explored and applied. Software solutions are confortable and new algorithms and/or techniques can be used very quickly into real applications. But their functionalities always depend on a used computer and its type. At the beginning the hardware realization of complex algorithms, e.g. for computer vision, seems to us that the developing process is more complicated and too long in comparisson with a software solution. But final results in the form of integrated circuits or an electronic board bring better imlemented solutions with specific features for different applications. New technologies targeted to embedded systems open new quality also in the computer vision field. The Thesis contributes to the hardware solutions of object detections based on FPGA technologies which is suitable for the presented applications not only for their cheaper costs but also for the important feature – reconfigurability. The state of the art in the fields FPGA technologies, Image algebra, embedded systems is described clearly and sufficiently in the Thesis. In my opinion, the author's subject is topical.

b/ Goals of the Ph.D. Thesis and originality of contributions

The main goal was development of a hardware oriented technique for objects detection suitable for its integration into embedded systems realized image recognitions with static and dynamic reconfigurable features. At the beginning, the author defined an hypothesis – developing hardware solution of the objects detection has to use very simple elements running in parallel and the solution has to be comparable with commercially used and applied under different environmental conditions. The defined goals were fulfilled with promising results in the form of designing new object detection method targeted to FPGA technology (XILINX family has been explored, resulted in Spartan-3E – XC3S1600E), methods for optimum size of used templates with relationship to image quality, methods for circuit adaptation to environmental changes using FPGA static or dynamic reconfigurations. The goals are described clearly in the Thesis and they were realized, tested on real life application – "license plate detection on cars"; definitely the Thesis brings new ideas, the theoretical base, new techniques for objects detections and originality.

d/ Resuts, outcomes and publications

The contribution should be divided into 4 main parts: (1) mathematical definitions in shorter and/or simple forms needed for the proposed object detection techniques, (2) an original method for objects detection close to FPGA XILINX implementation and finding an optimum number of templates for its applications; the reported results in the presented case study aimed to rectangular objects detection shown better or comparable results with the technique targeted to used in the Unicam system, (3) the additional result – application of the developed method to other types of objects, (4) proposals for adaptation of hardware to some changes in environment using static and

dynamic reconfigurations. Although the problem solved in the Thesis is old and many techniques are well implemented and explored, Luděk Bryan has developed hardware realization in the right way, after excelent analysis of XILINX devices family structures. All outcomes and results are very useful and helpful for real implementations and I believe also by a professional provider.

e/ Conceptual and formal methods used for Ph.D. Thesis preparation

The document consits of 12 parts (introduction, 8 chapters, disscusion, conclusion and one annex) with lists of used references (122) and own publications (17), lists of key words, used symbols and abbreviations. The work and results are described clearly and precisely. I appreciate the author's style very much documented by illustrative examples and 2 real applications. This reflects excellent author's knowledge and experiences in the Thesis field. Publication activity of Luděk Bryan is high; he presented the results in many world conferences. I had also several occassions to listen to some of his presentations during the seminars PAD and conferences held in Slovakia. I recommed to publish the presented method and achieved results in a journal. The Thesis, publications and presentating achieved theoretical and practical results shown not only very good scientific erudition of Luděk Bryan but also his excellent filling for transfering theoretical results into real applications.

As to the formal style I have found only some minor errors in the text, e.g.:

- It seems to me unusual to underline words in definitions.
- Some mathematical expressions are numbered, but others not.
- Obviously description of a method is not done through definition (Definition 5.1.1, page 33).
- Description of Table 6.1 (page 54) is not correct. The table shown characteristics of different features of some selected devices from the XILINX device family.
- You have evaluated your synthesis results (page 58) as „low". If we present such evaluation, it is necessary to present, what does it means „low" – in comparission with the whole area of a chip, or with other techniques, or other used technology.
- In some places you have described or evaluated results in a chapter which are described in the later one (e.g. page 55). It seems to me not good style for readers.

Ouestions to the disscusion:

- It was not clear for me which definitions have been defined by you and which were used from other publications. It is not clerly written in the text.
- If your theoretical part is simpler in comparison with used till now, it could be useful to show e.g. one mathematical definition and why it was complex or unsuficietly for your theoretical aparat that you have had to redefine.
- Is it possible to compare your hardware solution of objects detection with parallel software implementaion, e.g. on grid computing systems, if it is publish?
- How does your methods should be applied for detection of two or three object on cars (example from the case study) – e.g. besides of „plate license" also an object characterized country?

The submitted Ph.D. Thesis by Luděk Bryan fulfil all requirements of a Ph.D. work, general requirements to award the Ph.D. title. I recommend this work for the Ph.D. defence.

Bratislava, October, 31 2007

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