Localization with a retinal camera

I. Introduction

Advantages:
low latency
[1][2][3][4]

II. Summary (1 page)

The last 10 years have seen many progress in autonomous robotics. The key enabler to autonomy were advances in robotic sensing hardware and the corresponding new techniques for dealing with the sensors data. For example, the introduction of the laser range finder as a standard robotic sensor allowed for the first time to have very reliable localization and mapping, through the introduction of the probabilistic/Bayesian paradigm (Markov localization, particle filters, etc.). Those simultaneous advances in sensors and theory enabled autonomous exploration of large scale environments and ultimately the feasibility of applications such as autonomous cars. Currently a large amount of research is devoted to monocular vision, which will be the key technology in the next 5 years, especially for micro aerial vehicles, whose limitations in payload and the outdoors operations prevent using clunky and power-hungry sensors like range-finders.

But, looking farther in the future, what will be the sensor modality of the future, and what theoretical paradigm needs to change to take advantage of it? Our view is that *dynamic sensors* in the style of the DVS camera are the most likely answer. The reasoning is simple: the performance of autonomous robots, measured by agility, in tasks such as exploration mainly depends on the accuracy of perception. In particular, in a sense-plan-act architecture what matters is the latency of the pipeline. The latency depends on the frequency of the sensor data, plus the time it takes to process the data. It is typical in current robots to have latencies of 200ms or more. This puts a hard bound on the agility of the platform. A DVS camera virtually eliminates the latency: data is transmitted using events that have latency in the order of few microseconds. However, this incremental information is completely different than the data we have now from traditional sensors, so that a new paradigm is needed to deal with this data. Moreover, the sensors that so far have been designed for general purpose use must be adapted to the case of robotics.

This transcontinental interdisciplinary collaborative project is dedicated to paving the way for widespread use of dynamic sensors in the field of robotics, from both the theoretical and the practical point of view. The three partners provide a unique set of competencies. The Institute of Neuroinformatics (Dr. Delbruck) is a leader in the design and production of neuromorphic dynamic vision sensors. University of Zurich (Prof. Scaramuzza) is a leader in perception and control for micro-aerial vehicles, which are the reference platform for the project. Caltech (Dr. Censi) brings the competencies for dealing with low-level sensorimotor data and for designing control architectures.

This project is particularly well suited to Sinergia because it is the only institutional source of funding that allows transcontinental collaborations with US partners. Moreover, Prof. Scaramuzza and Dr. Censi are young scientists at the beginning of the research career.

III. Research plan

A. Current state of research in the field

Making reference to the most important publications, particularly by other authors, please explain: - which previous insights provided the starting point and basis for the planned studies; - in which areas research is needed, and why; - which important, relevant research projects are currently underway in Switzerland and abroad.

B. Current state of your own research

For a new application, please present the research work that the various (co-)applicants have already undertaken in the relevant field or in related fields and mention the corresponding publications.

C. Research plan of the entire project

Based on the information provided under 2.1 and 2.2, please indicate: - the benefits expected from a cooperative approach (as a net- work); - the concrete overall goals that you expect to achieve in the course of the project; 2.3 - the scientific approach (combination of different methods, tech- niques, etc.) to be used in addressing the overall goals of the project. If the submitted project is declared as interdisciplinary, you must explain on approx. one page what this interdisciplinarity consists of, why it is essential and how it will be taken into consideration when the research plan is implemented.

D. Organization of the collaboration

Please answer the following questions: What scientific contribution is each of the sub-projects expected to make? How will the research work be structured as regards content and schedule? Which specific measures will be taken to enhance interaction (joint development of concept, continual exchange of knowledge, etc.) and to integrate results. Please specify the time and the means you will devote to this end? How will the collaboration of different groups in a network promote the education of young scientists (postdocs and doctoral candidates)?

E. Relevance and impact

Please describe the impacts you expect your research in the proposed project to have for the discipline and for science as a whole (research and education/teaching). In addition, please mention the form in which you wish to make your research results public (arti- cles in science journals, monographs, conference proceedings etc). If applicable, please indicate whether and to what extent the proposed project will have a broader impact and what this impact will be.

IV. Subproject 1

Please compile a research plan for each of the sub-projects involved. The research plan of a sub-project must not exceed 10 pages and 40,000 characters (with spaces), illustrations, formulae, tables and bibliographies included. A minimum of point 10 font size and 1.5 line spacing must be used.

A. Interactions with the overall project

Please explain how this sub-project is linked to the other sub- projects and to the overall project.

B. Detailed research plan

Please specify the approach you are taking and the concrete objec- tives that you aim to achieve in the period of funding. The following points should be addressed:

References

[1] M. Boerlin, T. Delbruck, and K. Eng. "Getting to know your neighbors: unsupervised learning of topography from real-world, event-based input". In: *Neural computation* 21.1 (2009) DOI:10.1162/neco.2009.06-07-554.

[2] P. Lichtsteiner, C. Posch, and T. Delbruck. "A 128 times; 128 120 dB 15 μs Latency Asynchronous Temporal Contrast Vision Sensor". In: *Solid-State Circuits, IEEE Journal of* 43.2 (2008) DOI:10.1109/JSSC.2007.914337.

[3] R Etienne-Cummings. "Intelligent robot vision sensors in VLSI". In: *Autonomous Robots* 7.3 (1999) (link) (url).

[4] M Oster, Y Wang, R Douglas, and S. C. Liu. "Quantification of a spike-based winner-take-all VLSI network". In: *Circuits and Systems I: Regular Papers, IEEE Transactions on* 55.10 (2008) (link) (url).