# Scientific Report

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| Nationality | Colombian |
| Name of the *Host Organisation* | Technical Research Centre of Finland (VTT) |
| First Name / family name of the *Scientific Coordinator* | Petri / Honkamaa |
| Period of the fellowship | 01/05/2012 to 30/04/2013 |

# I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

SLAM algorithms solve concurrently two interrelated problems: what is my current location (localization) and what does the around environment looks like (mapping). Solving these two problems is difficult because localization depends on mapping and mapping depends on localization. Therefore, errors in any of these steps lead to wrong maps and failure. SLAM is important because it is the core algorithm in many applications such as augmented reality, autonomous navigation in robots and aerial vehicles, among others. The sensors that are most common used in these applications are range-lasers, cameras and structured light sensors (e.g. Kinect). Nevertheless, localization and mapping based on visual sensors is currently a very active topic of research because cameras are able to provide good resolution while being portable and inexpensive devices. For example, the camera on a mobile phone can turned into an augmented reality port where additional information can be displayed to the user.

Mono-vision-based SLAM algorithms generally rely on feature detection, data association, localization and mapping as follows:

- Feature Detection: discriminative positions in the image are extracted. The most common detectors are FAST, Good Features to Track, Harris. Their task is to find positions in the image that can easily found in following frames, e.g. high curvature points that are the result of texture or geometric discontinuities in real world objects. These features are assumed to be the projection of 3D landmarks in the image that are later integrated in our built map.
- Data Association: landmarks in the map are matched to positions in the current image. Some of the most common algorithms are Nearest Neighbor (NN), Joint Compatibility Branch and Bound (JCBB), Active Search, One-Point-Ransac, Active Matching, Scalable Active Matching.
- Localization: the correspondences between landmarks in the map and their position in the image are used to estimate the new position. Algorithms for position estimation can be optimization-based like bundle adjustment or probabilistic based like Extended Kalman filter (EKF) or FastSLAM.
- Mapping: Updates the position of landmarks based on the current information and integrates new landmarks into the map.

Data associations is an important part of visual SLAM because it provides the essential information for doing localization but also defines which features can be added as new landmarks in the map. Data association is challenging mainly because:

- Feature detectors are not perfect and produce missdetection (the landmark is visible but is not detected).
- Landmarks can be occluded by closer objects with respect to the camera (landmark visibility is line-of-sight dependent).
- Data association is an NP-Hard problem because the number of association hypothesis grows exponentially with each time step (in the deterministic case) and within each frame (in the probabilistic case), i.e. enumerating exhaustively the possible association hypothesis is not feasible in common applications even for a small number of landmarks and features. Approximations have to be made.

An algorithm for data association for visual-based SLAM algorithm with the following novelty is proposed: Obtaining robustness by propagating multiple weak data association hypothesis over propagating only one strong hypotheses as it is usually done in SLAM algorithms in literature.

## II – PUBLICATION(S) DURING YOUR FELLOWSHIP

- **M. Soto-Alvarez**, P. Honkamaa, "Multiple Hypothesis Data Association Propagation for Robust Monocular-based SLAM Algorithms", (To be submitted in May 2013)

  **Abstract:** Data Association is probably the most important step of every monocular Simultaneous Localization and Mapping (SLAM) algorithm because it provides the basic information to the estimation step, independently on the estimation algorithm of choice. Although important, it is also a difficult task because the analytic solution is an NP-Hard problem. The usual approximation is to obtain one data association solution per frame which affects the robustness of the algorithm [1][2][3][4][5]. In this paper a data association approach is presented where multiple hypothesis are propagated between frames in a probabilistic framework. Experimental results, using real and synthetic data, show that the proposed algorithm performs better than state of the art methods.

  **References:**


  [1] M. Chli and A. J. Davison. Active matching for visual tracking. Robotics and Autonomous Systems, 57(12):1173 – 1187, 2009.

  [2] J. Civera, O. G. Grasa, A. J. Davison, and J. M. M. Montiel. 1-point ransac for ekf-based structure from motion. In IROS, pages 3498–3504. IEEE, 2009.

  [3] A. J. Davison. Active search for real-time vision. In In Proceedings of the IEEE International Conference on Computer Vision, pages 66–73, 2005.

  [4] A. Handa, M. Chli, H. Strasdat, and A. J. Davison. Scalable active matching. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2010.

  [5] J. Neira and J. Tard´os. Data association in stochastic mapping using the joint compatibility test. IEEE Transactions on Robotics and Automation, Vol. 17(No. 6):pp. 890 – 897, December 2001.


## III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

- **Ercim Seminar**, Fall meeting, 24-26 October 2012, Sopia Antipolis, France

## IV – RESEARCH EXCHANGE PROGRAMME (REP)

- **REP 1**: 24.09.2012-28.09.2012,
  Fraunhofer Institute, Heinrich Hertz Institute, Berlin
  Local coordinator: Peter Eisert peter.eisert@hhi.fraunhofer.de
  During my stay I have given a seminar about my research and obtained information about Dense Reconstruction, which is one of the strong fields of the visited group.

- **REP2**: 11.02.2013-15.02.2013,
  CNR Pisa, Italy.
  Local coordinator: Dr Giuseppe Amato giuseppe.amato@isti.cnr.it
  During my stay I have given a seminar about my research and obtained information about information retrival which is one of the strong fields of the visited group.