

Hybrid sensor fusion with dual quaternion based EKF for pose estimation in real-time

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Master thesis kick-off presentation

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Project partner : FRAMOS GmbH

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Introduction

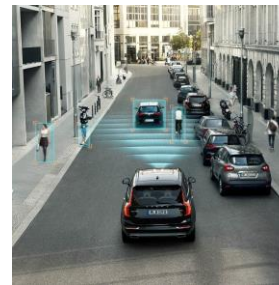
- Various tracking technologies have been developed (optical, inertial, EM sensors) along with the improvement of the modern cameras.
- More robust and efficient algorithms are being implemented for tracking and pose estimation.
- Many possibilities for applications to be used to (AR setups, medical robotics, autonomous flying / driving, entertainment).



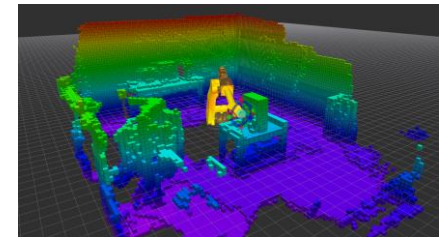
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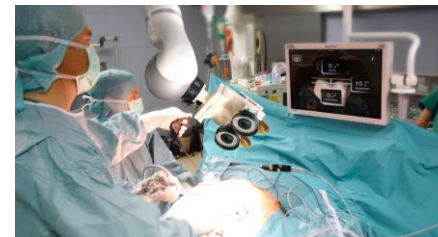
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Motivation

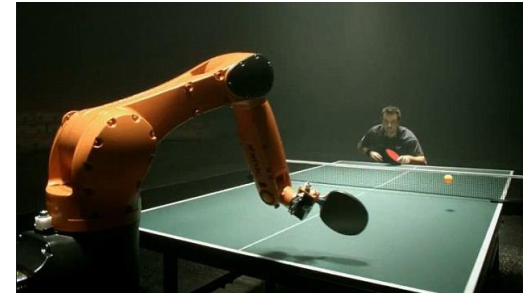
- Each sensor has strengths and weaknesses
- Need for use of more than one sensor for better precision
- Line-of-sight issues from optical tracking should be resolved
- IMU's fast sampling rate benefit the system
- More robust algorithms for improving speed and accuracy
- Real-time applications
- Sensor prize / economical aspects

Previous work and State of the art

- Lots of studies about sensor fusion and pose estimation with the use of various filters
 - Comparison of extended and unscented Kalman filter performance for evaluating a navigation information system¹
 - Playing with a table tennis robot - Tracking the trajectory of the racket on player's hand by fusion of vision and IMU sensors data²
 - System for indoor 3D position tracking with an inertial measurement unit and a marker-based video tracking system utilizing external cameras³



<https://budbrownvw.files.wordpress.com/2016/06/volkswagen-navigation.jpg>



<http://www.bestpingpongtables.review/wp-content/uploads/2016/08/pingpong.png>

1. Mathieu St-Pierre, Denis Gingras Comparison between the unscented Kalman filter and the extended Kalman filter for the position estimation module of an integrated navigation information system. Intelligent Vehicles Symposium.(2004)
2. Kun Zhang, Zaojun Fang, Jianran Liu, Zhengxing Wu, Min Tan. Fusion of Vision and IMU to Track the Racket Trajectory in Real Time. International Conference on Mechatronics and Automation (2017)
3. Bastian Hartmann and Gert F. Trommer. Indoor 3D Position Estimation Using Low-Cost Inertial Sensors and Marker-Based Video-Tracking. Position Location and Navigation Symposium (PLANS),(2010)

Previous work and State of the art

- Many studies using dual quaternion formalization for efficiency
 - Frameworks based on Dual Quaternions for fusion of inertial data⁴
 - Pose estimation using dual quaternion based Kalman filter to represent the SE(3) element⁵
- Cutting edge for Spacecraft pose estimation using dual quaternions and extended Kalman filter⁶

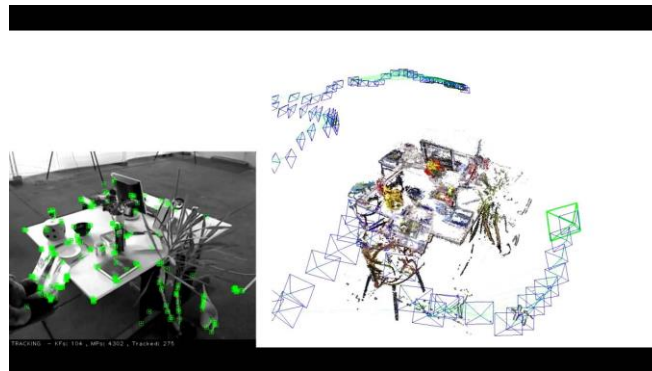


<http://2.cdn.turner.com/money/dam/assets/170822111231-lockheed-martin-orion-780x439.jpg>

4. Wang Yuyang, Yan Peiyi, Zhang Chunyang, Liu Zheming. A Dual Quaternion Based Fusion Framework for IMU Data with 6 DOF Pose. Journal of Electronics and Information Science (2016) 1: 22-31
5. Srivatsan, R. A., Rosen, G. T., Mohamed, D. F. N., & Choset, H. (2016). Estimating SE (3) elements using a dual quaternion based linear Kalman filter. In Robotics: Science and Systems.
6. Nuno Filipe, Michail Kontitsis, Panagiotis Tsiotras. Extended Kalman Filter for spacecraft pose estimation using dualquaternions. American Control Conference (ACC), (2015)

Previous work and State of the art

- Cutting edge for sensor fusion along with the use of vision cameras:
 - ORB-SLAM2 (SLAM - Simultaneous localization and mapping) System for Monocular, Stereo and RGB-D Cameras⁷
 - Visual-Inertial Odometry – visual odometry from the stereo camera is fused with the inertial measurements using an error-state extended Kalman filter⁸
 - Visual-Inertial Monocular SLAM With Map Reuse⁹



<https://i.ytimg.com/vi/HBmq70LKrQ/maxresdefault.jpg>

7. Raúl Mur-Artal and Juan D. Tardós. ORB-SLAM2: an Open-Source SLAM System for Monocular, Stereo and RGB-D Cameras. IEEE Transactions on Robotics, DOI: 10.1109/TRO.2017.2705103. (2017)

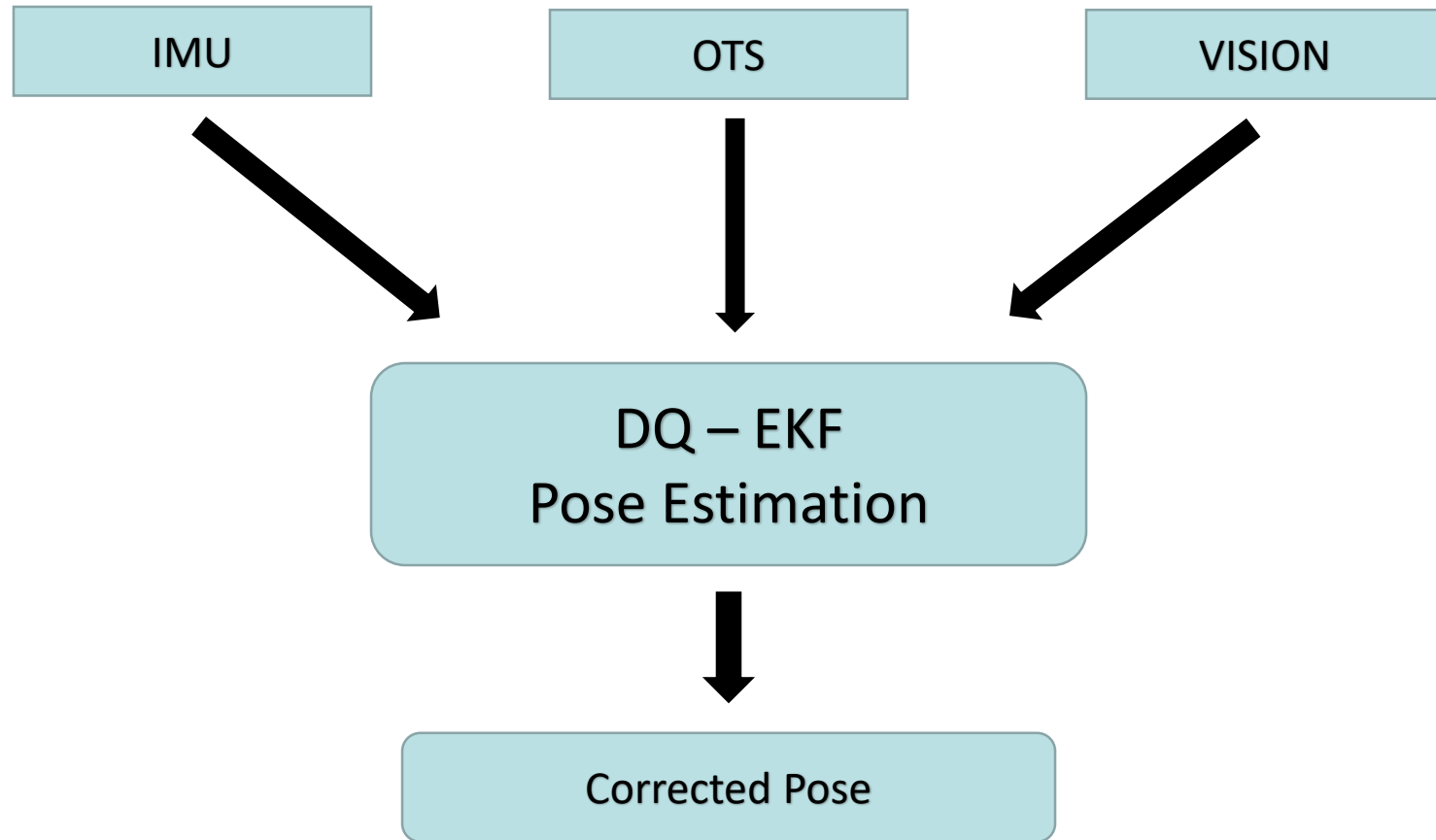
8. Manuel Schwaab, Michailas Romanovas, Davide Plaia, Tobias Schwarze, Yiannos Manoli. Fusion of Visual Odometry and Inertial Sensors Using Dual Quaternions and Stochastic Cloning. International Conference on Information Fusion.(2016)

9. Raúl Mur-Artal and Juan D. Tardós. Visual-Inertial Monocular SLAM With Map Reuse. IEEE ROBOTICS AND AUTOMATION LETTERS, VOL. 2, NO. 2, APRIL 2017

Thesis overview

- Implementation of a generic algorithm for pose estimation out of measurements from more than one sensor
- Use of dual quaternion mathematic formalization for compact and more efficient calculations
- More accurate formulation with non-Euclidean approximation
- Use of the Extended Kalman filter (EKF) for tightly-coupled filtering
- Trials on synthetic and real data or existing datasets
- Comparison with other methods or filters

Thesis overview



Work so far

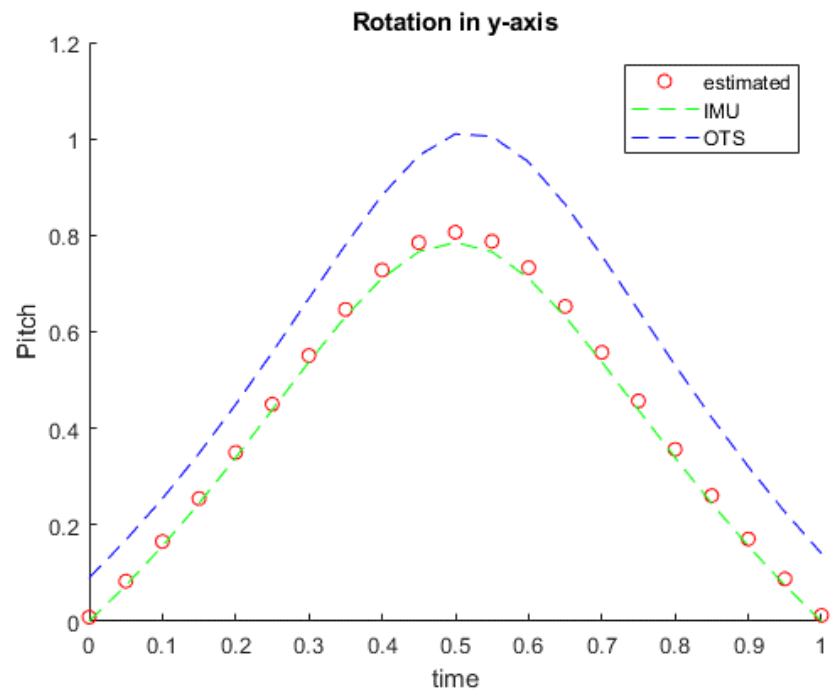
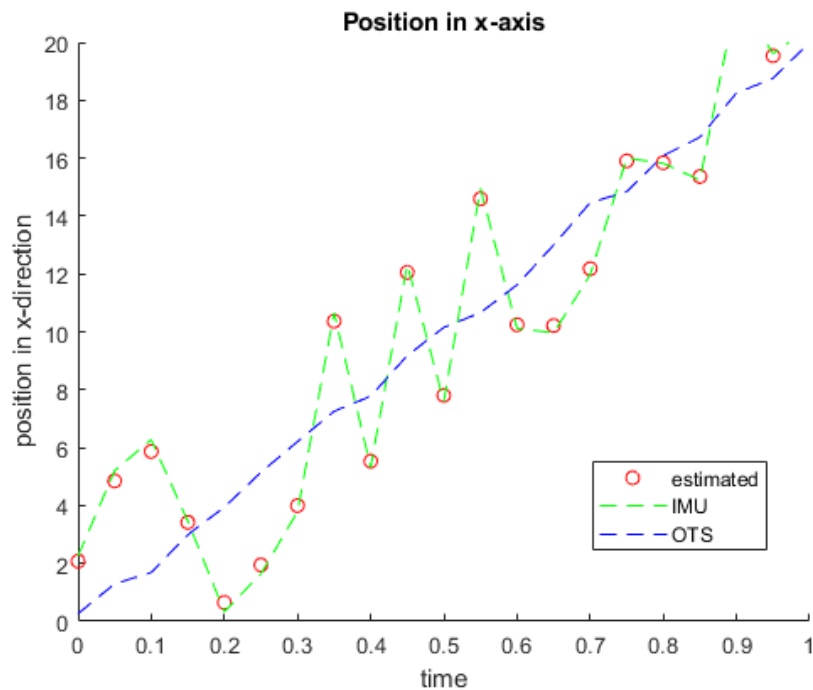
- Review of the literature and state of the art
- Prototype of the EKF in MATLAB based on “Dual Quaternion based IMU and Vision Fusion Framework for Mobile Augmented Reality” Varghese, 2015



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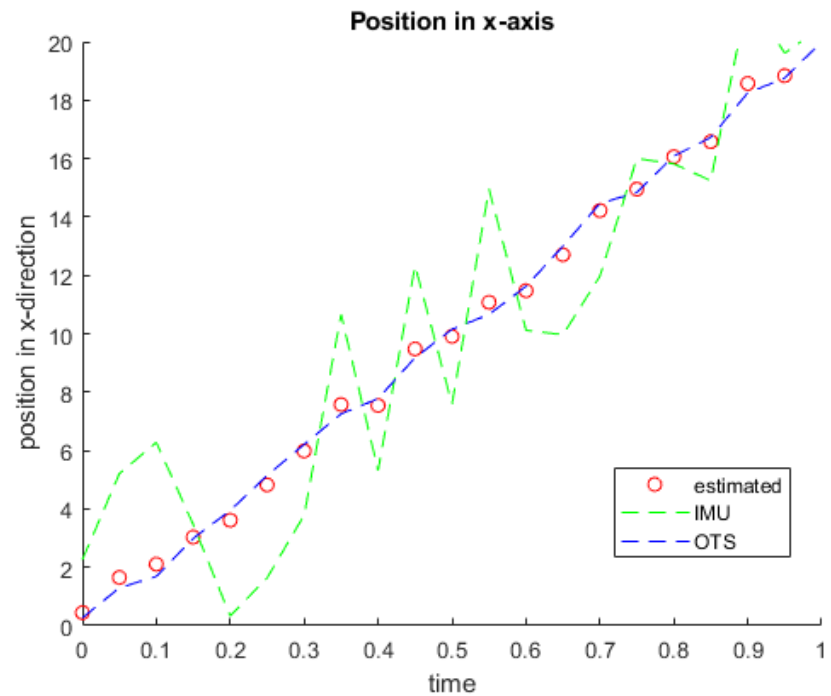
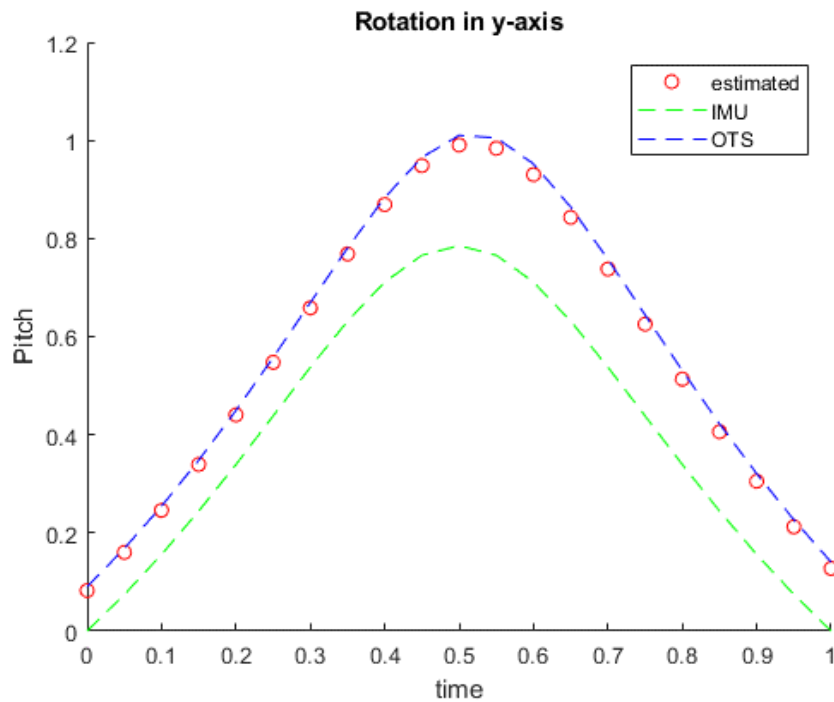
Work so far

- IMU dominant



Work so far

- OTS dominant



Thank you
for your attention!