A HUMAN ARM MOTION TRACKING SYSTEM DESIGN USING AN IMU AND A CAMERA SENSORS

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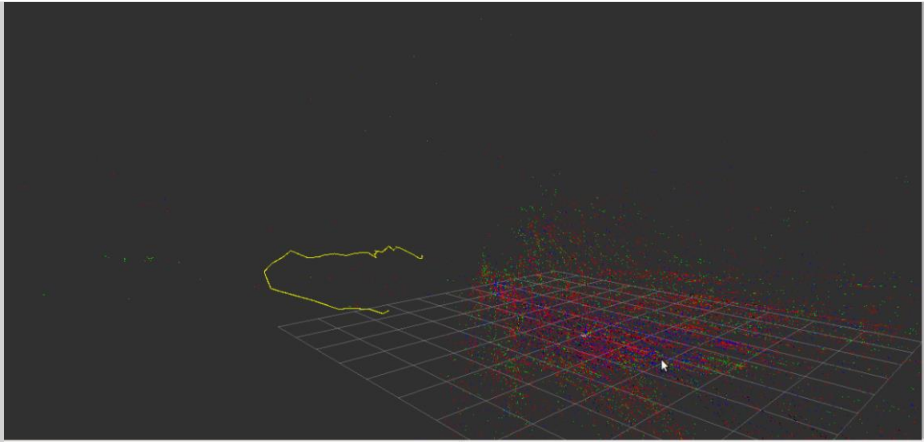
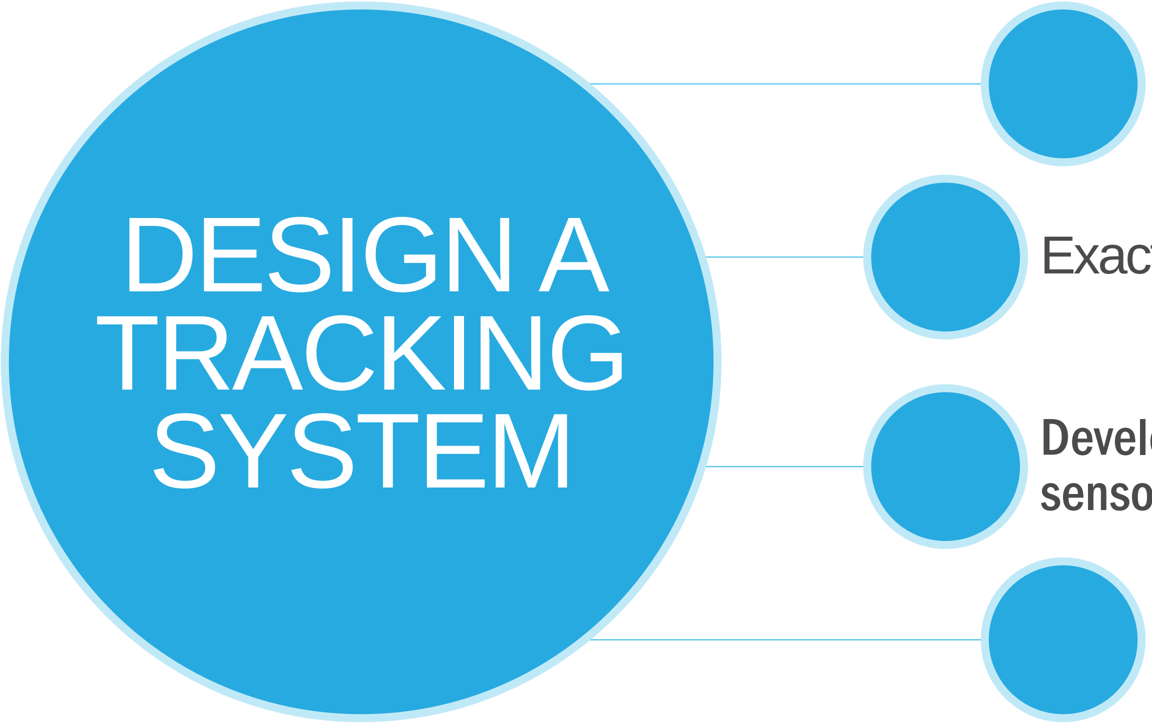


PROJECTOBJECTIVES



DESIGN A TRACKING SYSTEM

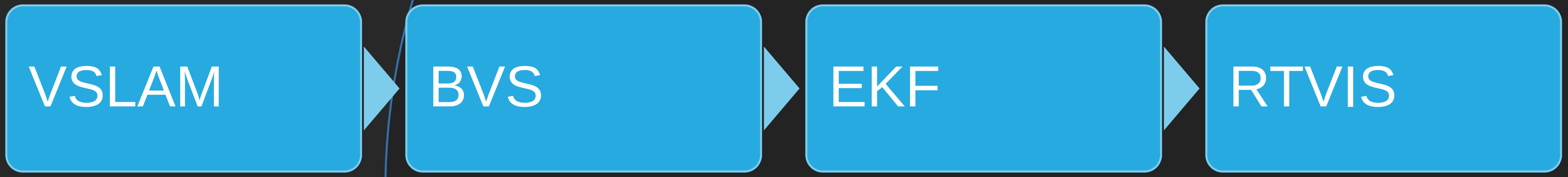
Precise orientation of the hand in 3D

Exact path of the body

Development of a multi-sensor fusion framework

Create a user friendly interface

KEY PROJECT COMPONENTS



Visual Simultaneous Localization and Mapping

Camera as Body-Velocity Sensor augmented by IMU

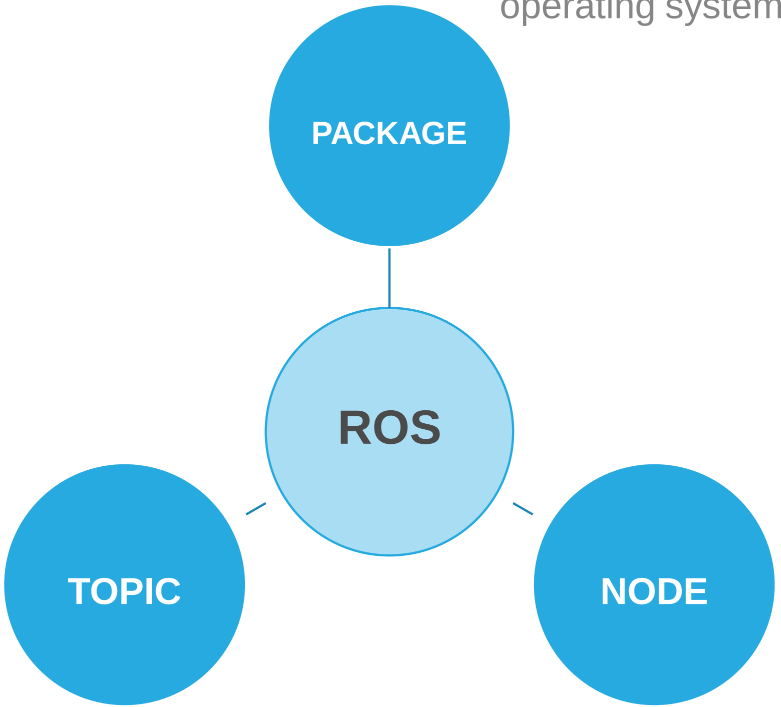
Extended Kalman Filter Sensor Data Fusion

Real Time Visualization

HYDRO ROS GROOVY

ROSROBOTIC OPERATION SYSTEM

Is a collection of software frameworks for robot software development, providing operating system-like functionality on a heterogeneous computer cluster

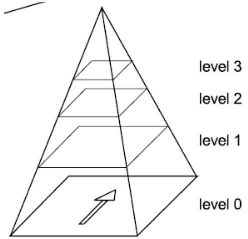


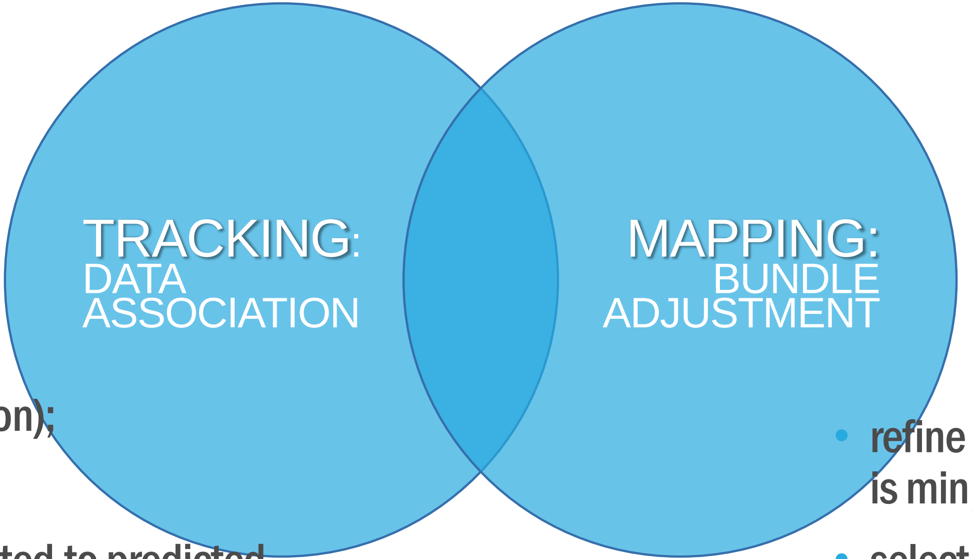
PACKAGE MIGHT CONTAIN ROS NODES, ROS-INDEPENDENT LIBRARY, A DATASET, CONFIGURATION FILES OR ANYTHING THAT CONSTITUTES LOGICALLY USEFUL MODULE

NODE IS AN EXECUTABLE FILE WITHIN A ROS PACKAGE. CAN PUBLISH AND SUBSCRIBE TO A TOPIC

TOPIC IS A NAMED BUS OVER WHICH NODES EXCHANGE MESSAGE

CAMERA AS POSE SENSOR VSLAM





TRACKING: DATA ASSOCIATION

MAPPING: BUNDLE ADJUSTMENT

- store map (calibration);
- predict new pose;
- map features projected to predicted pose;
- search for corresponding features.

- refine orientation and position: total erro is min;
- select key-frames to build a 3Dmap;
- batch optimization to refine map points/key-frame poses;

PTAM OF Klein and Murray, 2007, P.25

CAMERA AS A MOTION SENSOR BVS

- Feature management: ensures enough features equally spread in the image
- Feature extraction and matching establishes correspondence in consecutive frames;
- Visual velocity calculations: 2D Continuous “8-point” Algorithm.

$$\vec{u}^T \lfloor \vec{v}(t) \rfloor \vec{x} + \vec{x}^T \lfloor \vec{\omega}(t) \rfloor \lfloor \vec{v}(t) \rfloor \vec{x} = 0$$

$$\boxed{(\lfloor \vec{u}(t) \rfloor \vec{x})^T \vec{v} \quad = \quad 0}$$

$$\dot{\lambda}_i(t)\vec{x}_i(t) + \lambda_i(t)\dot{\vec{x}}_i(t) = \eta\vec{v}(t) \ .$$

$$\boxed{M\vec{\lambda} = 0}$$

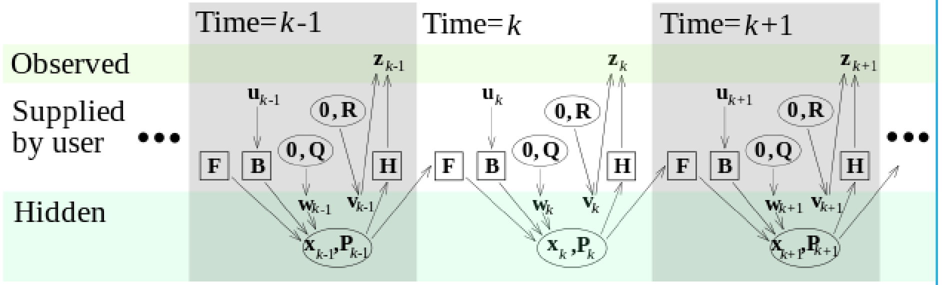
Weiss, 2012, P.47

SENSOR DATA FUSION EKF

Kalman filter (KF) effective recursive filter, which evaluates the state of dynamic system

Real case
(non-linear dynamics and unpredictable noise)

EKF - is the nonlinear version of the Kalman filter which linearizes about an estimate of the current mean and covariance



$$\mathbf{x}_k = \mathbf{F}_k \mathbf{x}_{k-1} + \mathbf{B}_k \mathbf{u}_k + \mathbf{w}_k$$

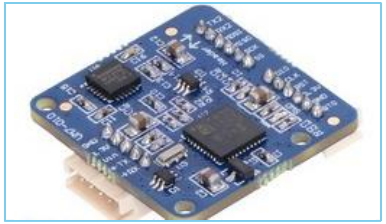
Weiss, 2014, p61

$$\boldsymbol{x}_k = f(\boldsymbol{x}_{k-1}, \boldsymbol{u}_k) + \boldsymbol{w}_k$$

$$\boldsymbol{z}_k = h(\boldsymbol{x}_k) + \boldsymbol{v}_k$$

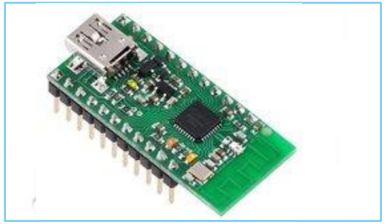
In the extended Kalman filter, the state transition and observation models don't need to be linear functions of the state but may instead be differentiable functions.

HARDWARE//COMPONENTS



POLOLU UM-LT7

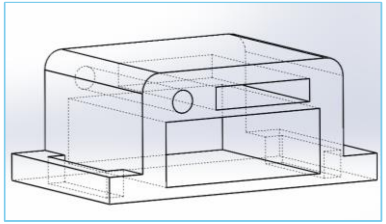
orientation sensor



POLOLU WIXEL

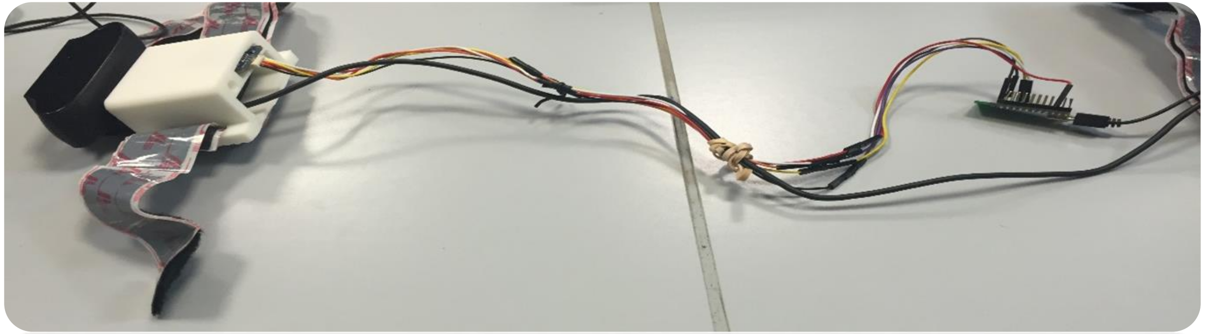
general-purpose programmable module

LOGITECH C920

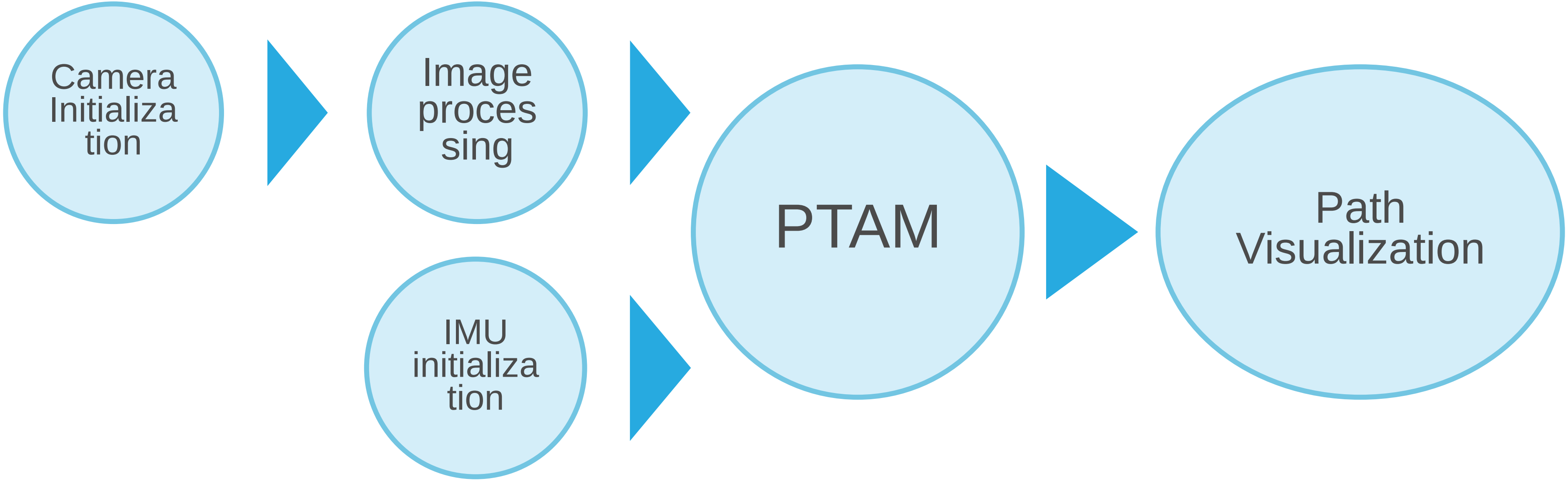


3D CASE

designed in solidworks



OVERALL ALGORITHM FLOW



Camera Initialization

Image processing

IMU initialization

PTAM

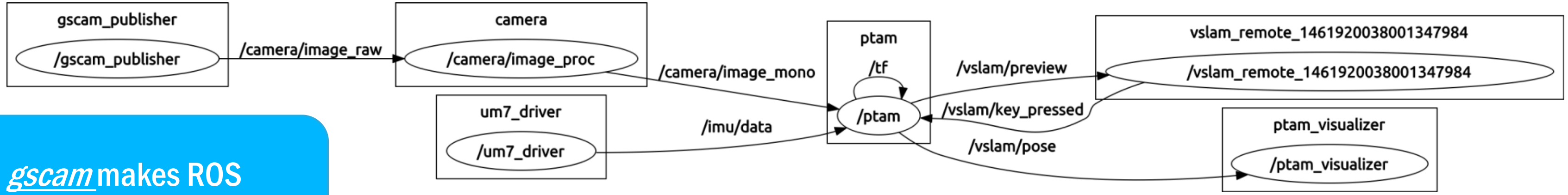
Path Visualization

ROS NODES LAYOUT

Image_proc removes camera distortion from the raw image stream

ptam modified version of SLAM framework, simplified and robust

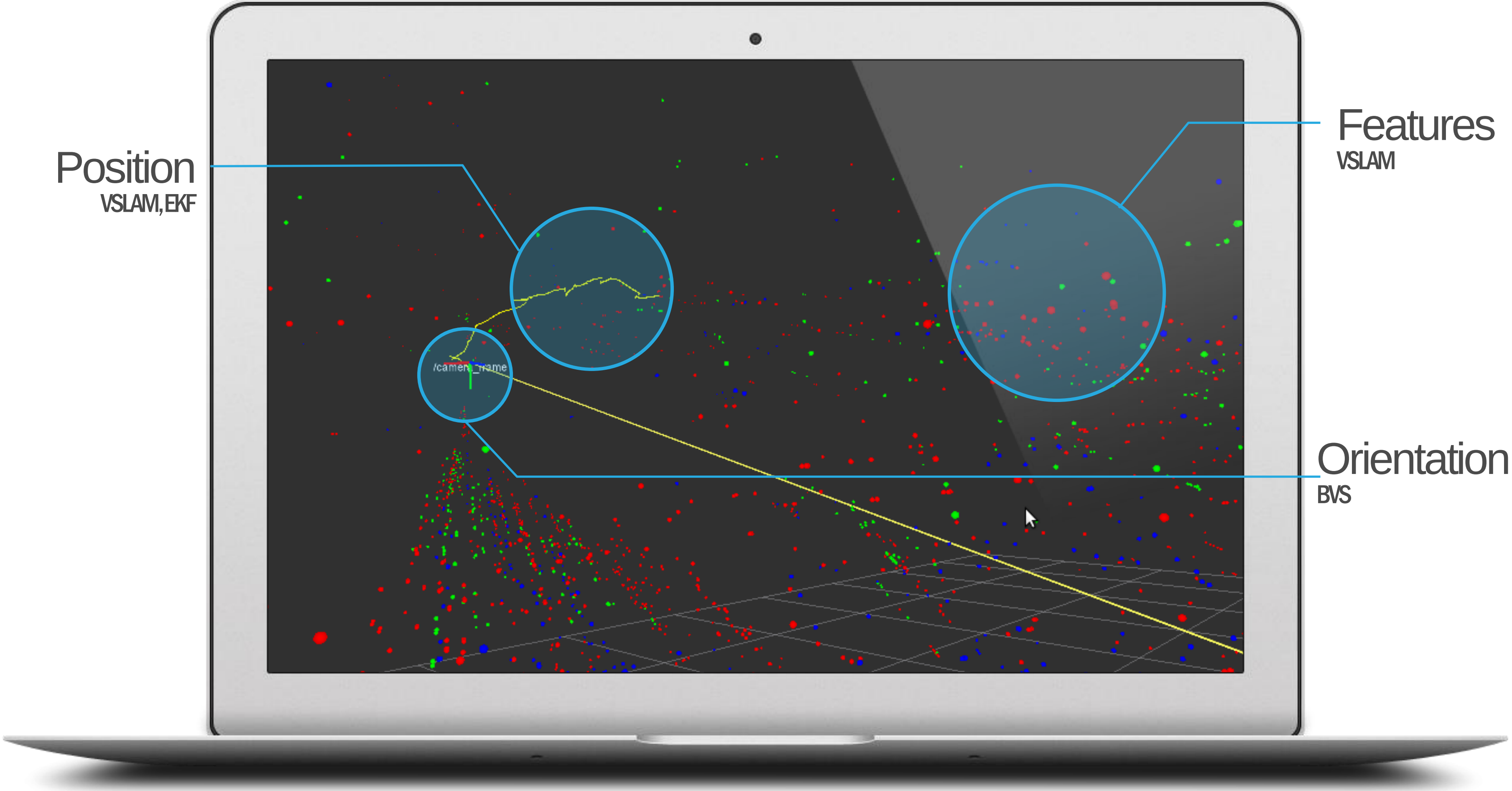
ptam-remote provides with visual preview during world frame initialization



gscam makes ROS compatible our camera

um7-driver streams data from the sensor in the form of filtered orientation, accelerations and angular rotation

ptam-visualizer manage the information to be displayed in RViz and to store the data in text files



Position
VSLAM,EKF

Features
VSLAM

Orientation
BVS

SYSTEM DEMONSTRATION

https://youtu.be/hH3-NnsnYU0

THIS SYSTEM CAN BE USEFUL IN DEVELOPMENT OF :

MEDICINE

Surgery, Rehabilitation

ADVANCE GPS

Which will remember the path.

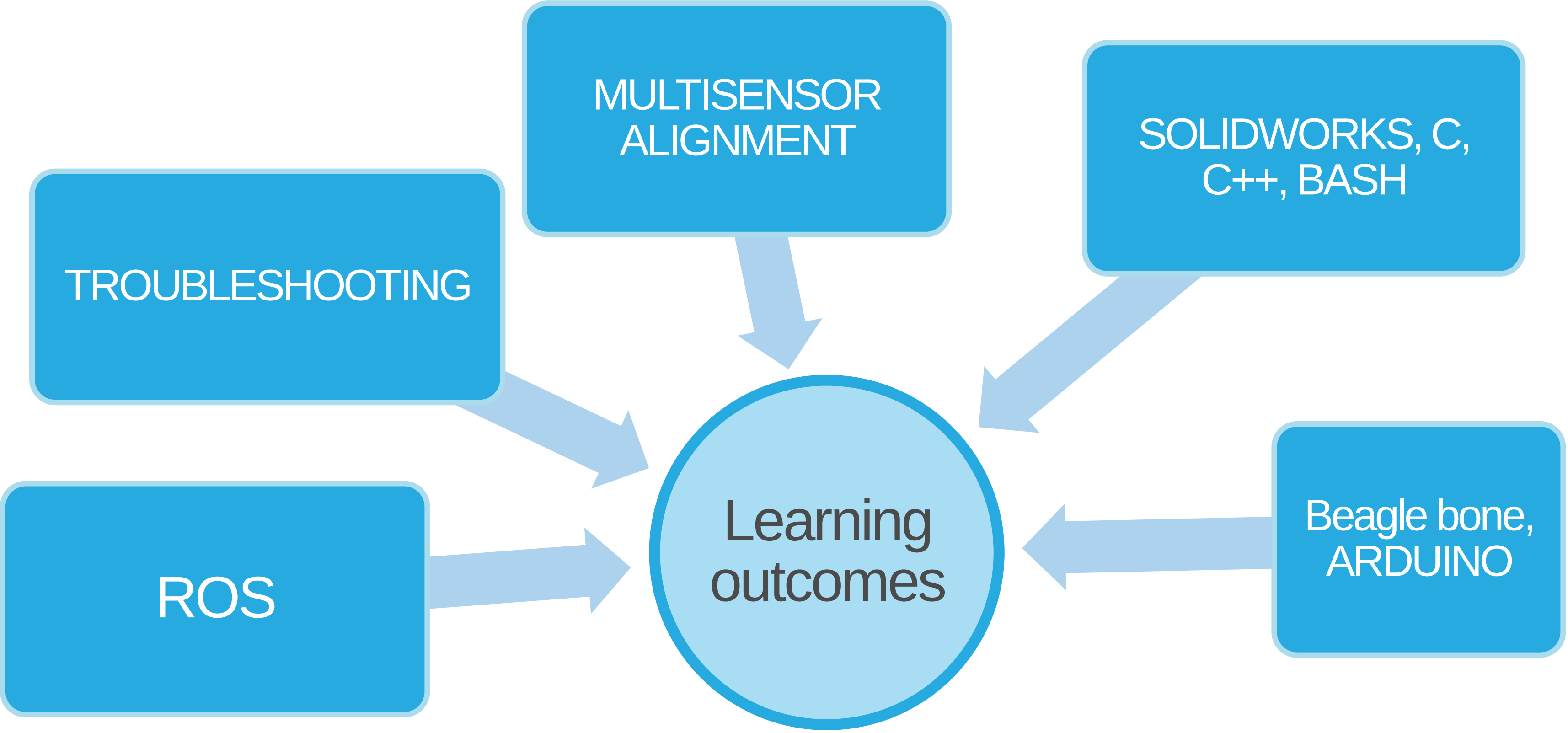
ENTERTAINMENT

Video games

NAVIGATION SYSTEM

Robots

ONCE YOU STOP LEARNING YOU START DYING



MULTISENSOR ALIGNMENT

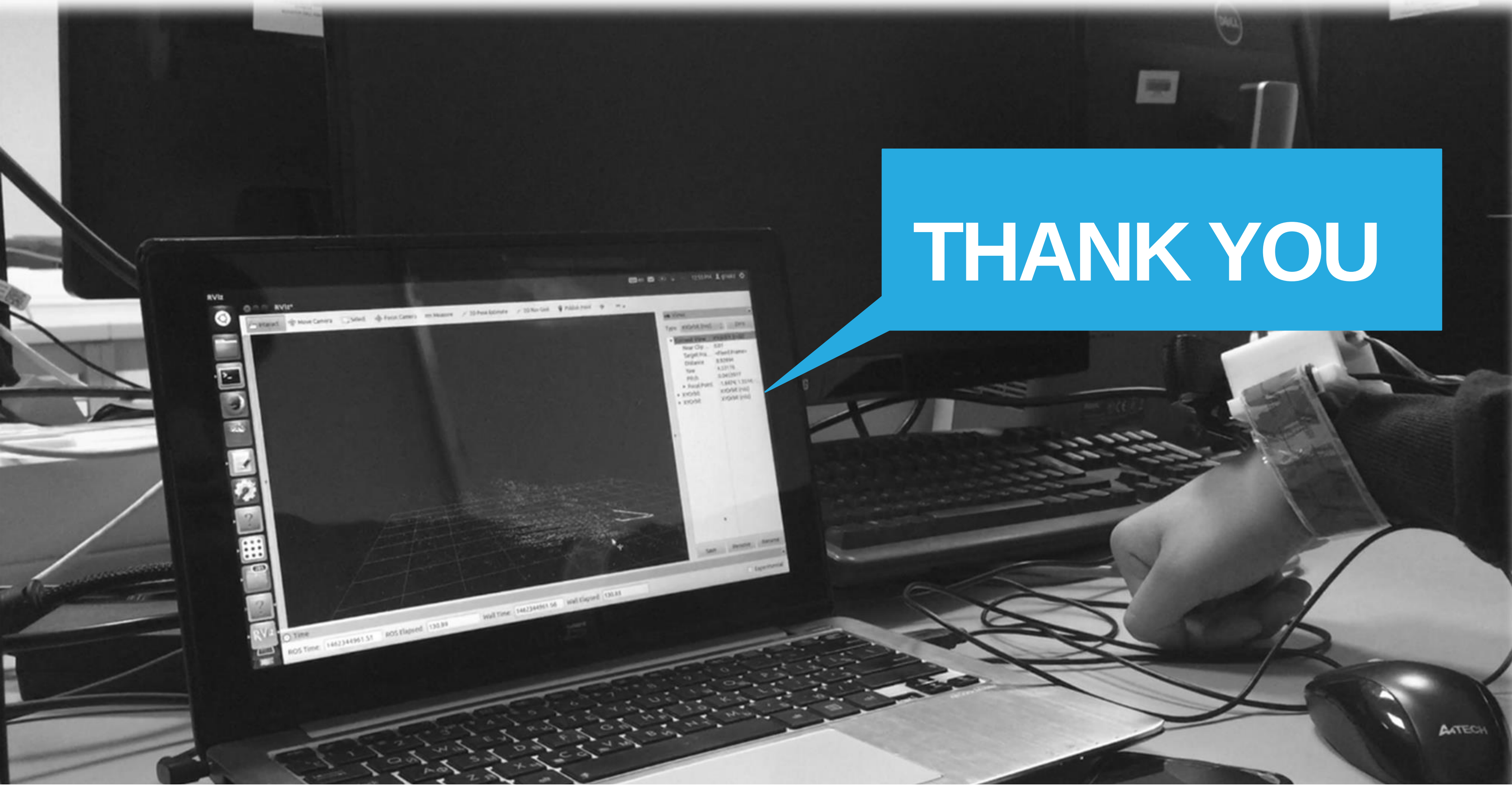
SOLIDWORKS, C, C++, BASH

TROUBLESHOOTING

ROS

Beagle bone, ARDUINO

Learning outcomes



THANK YOU

DIAS ALIMBAY | | NIGINA BAIMUKHAMEDOVA

REFERENCE:

1. Weiss, S., Scaramuzza, D. and Siegwart, R. (2011). Monocular-SLAM-based navigation for autonomous micro helicopters in GPS-denied environments. Journal of Field Robotics, 28(6), pp.854-874.

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3. Klein, G. and Murray, D. (2010). Simulating Low-Cost Cameras for Augmented Reality Compositing. IEEE Trans. Visual. Comput. Graphics, 16(3), pp.369-380.

4. Fernandez, E. (n.d.). Learning ROS for robotics programming.