Performance Enhancement of RTAB-map Utilizing ORB-SLAM2 Depth Information

Islam Ali
iaali@ualberta.ca

Zifei Jiang
zifei.jiang@ualberta.ca

UNIVERSITY OF ALBERTA

Agenda

- Introduction
- Problem Definition
- Literature Review
- Methodology and Procedure
- Performance Evaluation
- Significance of Proposed Research

Introduction

- **Wide Spectrum of Applications …**

https://www.amazon.com/Amazon-Prime-Air/b?node=8037720011

https://techcrunch.com/2016/08/11/teslas-autopilot-2-0-said-to-add-triple-camera-system-and-more-radar/

http://www.dji.com/newsroom/news/tags/phantom-2-vision-plus

http://www.datixinc.com/will-robot-job-2050/bot-and-dolly-scout/

https://www.ald.softbankrobotics.com/en/cool-robots/nao

Introduction

- **Wide spectrum of applications in many industries and disciplines sharing the similar needs in terms of perception of the world.**

- **Perception of the world became possible and feasible by the introduction of different types of low-cost sensors such as :**
  - Cameras, LiDARs, Radars, IMUs, GPS, among many others

Problem Definition

- Autonomous robotics are playing a vital role in all aspects of our lives and communities.
- The ability of the robot to have accurate perception of the surroundings and sense of location is essential.
- SLAM was the answer to both question, as it provides a model of the environment, and localize the robot inside it.

https://paperswithcode.com/task/simultaneous-localization-and-mapping

UNIVERSITY OF ALBERTA

Problem Definition

- Studies shown that, RTAB-Map and ORB-SLAM 1&2 are two state-of-the-art algorithms solving the SLAM problem.

- Both algorithms outperform most of the classical and modern SLAM systems.

- However, both suffer from performance issues under certain conditions and can provide wrong estimations for both the trajectory and the mapping.

UNIVERSITY OF ALBERTA

Problem Definition

- Looking into the details of RTAB-Map and ORB-SLAM2, we can infer potentials for Integration for a more reliable solution.

- The original RTAB-Map pointed out the possibility of integration and the performance gain modestly.

- In this work, we explore the possibility of embedding the depth information extracted from ORB-SLAM2 into RTAB-Map for performance enhancement.

Literature Review

- **RTAB-Map**
  - Open source graph-based SLAM, deeply integrated to ROS.
  - Mapping is separated from Odometry for efficiency.
  - Map created directly from depth information without optimization.
- **ORB-SLAM**
  - **Ver. 1** → Monocular only, while **Ver. 2** → Stereo and RGB-D
  - Optimization is done on camera poses and features points in the map (two levels of optimization)
  - ORB features are used in all stages (e.g. tracking, loop closure, ..)
  - Running 3 parallel threads for efficiency (tracking, local mapping, and loop closure)

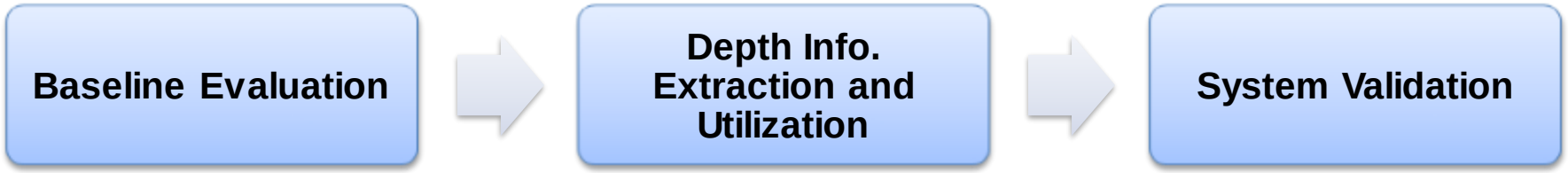
Literature Review

- **RTAB-Map vs. ORB-SLAM 2**

	RTAB-Map	ORB-SLAM2
Advantages	• Can accept a wide range of sensors as inputs. • Better trajectory estimation. • Better loop closure mechanism based on BoW. • Works better outdoors. • Dense map generation. • Better **RMS** trajectory error.	• Work with Monocular, Stereo, and RGB-D camera. • Better odometry measurements • Small number of outliers • Works better indoors • Strong loop closure resulting in rejection of false estimates. • Better **Max**. trajectory error.
Disadvantages	• Bad odometry measurements. • Repeated surfaces due to odometry noise. • Performance depends on the environment when using internal odometry engine. • Lack of map optimization.	• Long initialization / re-initialization time. • Sparse non-detailed map. • Missing loop closure and allow the trajectory drift to be visible.

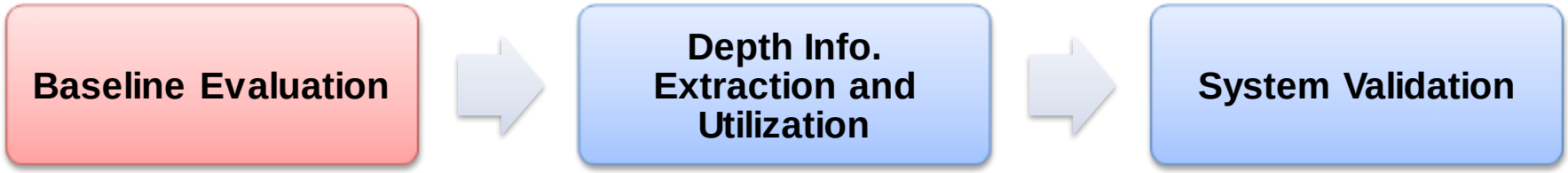
UNIVERSITY OF ALBERTA

Methodology and Procedure



UNIVERSITY OF ALBERTA

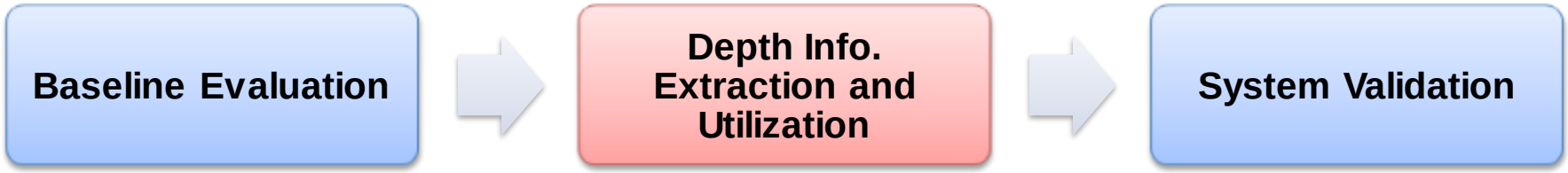
Methodology and Procedure



- **Baseline performance is the performance of both RTAB-Map and ORB-SLAM2 on the selected datasets.**
  - KITTI (for outdoor), and TUM RGB-D (for indoor)

- **Accuracy performance metrics are available in a number of studies, and can be replicated during the course of the research work.**

Methodology and Procedure



- **RTAB-map only perform local optimization on camera poses to minimize the re-projection error between matched 3D points in world coordinate frame and the camera observation.**

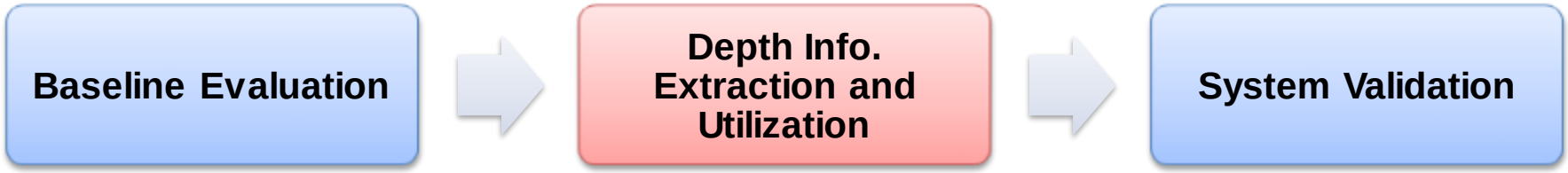
$$\{\mathbf{R}, \mathbf{t}\} = \underset{\mathbf{R},\mathbf{t}}{\operatorname{argmin}} \sum_{i \in \mathcal{X}} \rho(||x^i - \pi(\mathbf{R}\mathbf{X}^\mathbf{i} + \mathbf{t})||^2)$$

- **ORB-SLAM2 optimize the feature points in the map, and can provide more accurate depth information for feature points in keyframes.**

$$\{\mathbf{X}^\mathbf{i}, \mathbf{R_l}, \mathbf{t_l}\} = \underset{\mathbf{X}^\mathbf{i},\mathbf{R_l},\mathbf{t_l}}{\operatorname{argmin}} \sum_{k \in \mathcal{K}_L \cup \mathcal{K}_F} \sum_{i \in \mathcal{X}_k} \rho(||x^j - \pi(\mathbf{R_k}\mathbf{X}^\mathbf{j} + \mathbf{t_k})||^2)$$

UNIVERSITY OF ALBERTA

Methodology and Procedure

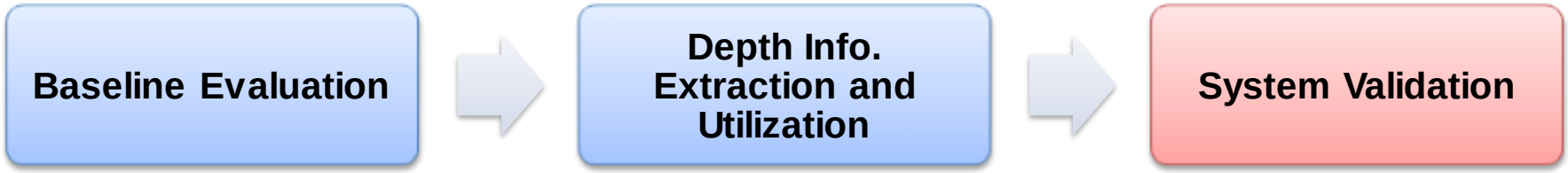


- **In this work, we will utilize the optimized keyframe generated by ORB-SLAM2 inside the RTAB-Map pipeline.**

- **Objectives are to achieve:**
  1. Better trajectory accuracy
  2. More reliable point cloud map

UNIVERSITY OF ALBERTA

Methodology and Procedure



- **System will be developed under ROS environment.**
- **Validation will be conducted using unified datasets exploiting different scenarios, and having a ground truth.**
- **Datasets selected are KITTI and TUM RGB-D.**
  - Covering indoor/outdoor static/dynamic conditions.

Performance Evaluation

- **In this work, we focus on Accuracy enhancement.**
- **Absolute Trajectory Error (ATE) was adopted by many as a measure for accuracy, ATE is defined by:**

$$ATE(t_i) = \|(x^*_{t_i}, y^*_{t_i}) - (x_{t_i}, y_{t_i})\|$$

- **To have a better representation of the error and its evolution, statistical measurements are applied to ATE.**
  - Max / Min ATE Error
  - Root Mean Square Error (RMSE)
  - Mean, median, variance, and std. deviation.

UNIVERSITY OF ALBERTA

Significance of Proposed Research

- **Extension of the boundaries of both Algorithms.**
- **More robust and reliable SLAM solution.**
- **Serve the ultimate objective of having an out-of-box SLAM system able to work under challenging conditions.**

Questions

Thank You !