6D pose tracking of bins without CAD model using RGBD data: evaluation of the BundleTrack algorithm

Koen Fierens

Technology Master of Electronics and ICT Engineering Technology

Problem

Introduction

The **Automatization, Computer vision & Robotics (ACRO)** research group of KU Leuven has developed a robot capable of picking up bins, or **palloxes**, in an orchard. To automate this process, it is crucial to determine the **six degrees-of-freedom (6D) pose** of a pallox, which refers to its position and orientation in three-dimensional space. A temporal tracking method **without a Computer Aided Design (CAD) model** is preferred over tracking by detection methods because of its faster processing time, which enables **real-time performance**. This is because **temporal tracking** uses the previous poses to track its position, while tracking by detection detects objects in each frame separately.

Method

6D pose calculation with BundleTrack

To calculate the 6D pose of the pallox, **RGBD data** captured by the **RealSense LIDAR L515 camera** is utilized. The solution involves using **BundleTrack** in conjunction with the **Segment Anything Model (SAM), Grounding DINO** and custom code. The working principle of BundleTrack is illustrated in Fig. 1(a) and consists of the following steps:

- The algorithm takes **RGB and RGBD images as input**.
- Then, Grounding DINO and SAM are used to **segment the object of interest**.
- Next, the **features** of the object are located, their **descriptors** are calculated, and they are **matched** with the previous frame.
- Afterwards, the **6D pose is determined** using the transformation matrix.
- Finally, **keyframes** are used to refine the estimated pose.

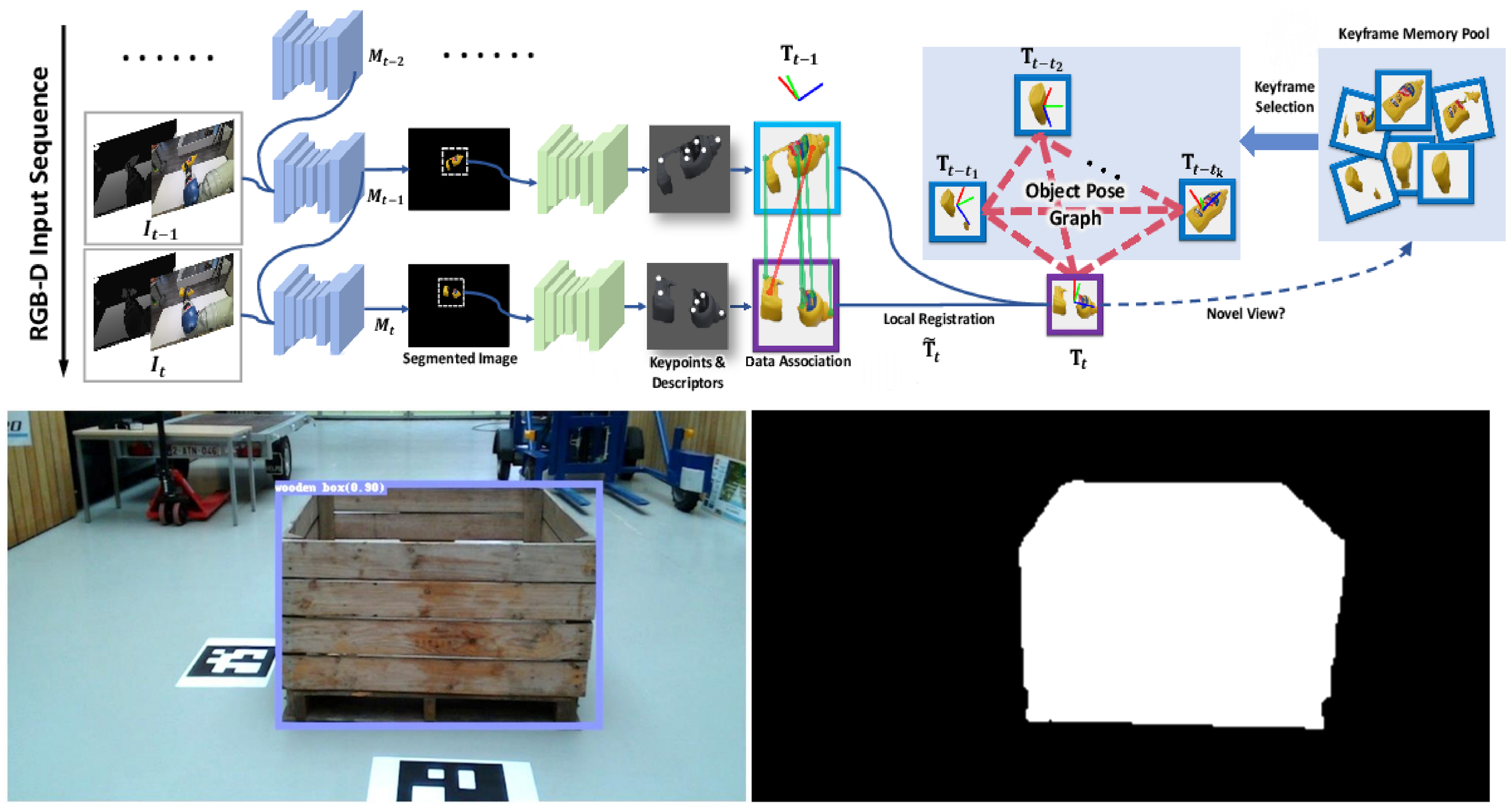

Figure 1: (a) Working principle of BundleTrack [1] (b) Output of Grounding DINO and SAM

Ground truth 6D pose calculation with 6DPoseAnnotator

ArUco markers were utilized to obtain the **ground truth**, necessitating the creation of a model. However, the results derived from this approach proved **unsatisfactory**. Therefore, the **6DPoseAnnotator algorithm** was employed instead. This algorithm uses the model to accurately determine the pose of the pallox. The program was used on **50 frames**, evenly distributed across all frames to cover a wide range of object angles and perspectives. Fig. 2 displays the 6DPoseAnnotator program in operation.

Figure 2: Visualization of the 6DPoseAnnotator program for obtaining the ground truth pose

Results

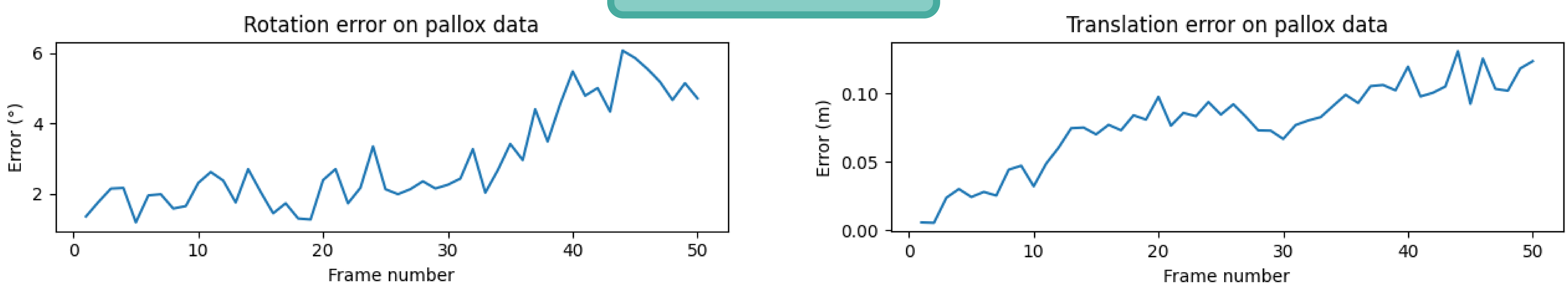

Figure 3: The rotation and translation error of BundleTrack on pallox data

Conclusion

Conclusion and future work

BundleTrack accurately estimates the 6D pose of the pallox, with an **average rotation error of 2.93°** and a **position error of 7.74 cm**. It achieves an **Area Under Curve (AUC)** of **26.17** measured by the Average Distance of Points (ADD) metric and **72.94** measured by the Average Distance of Points Symmetry (ADD-S) metric. In this paper, the proposed algorithm was tested using an AMD Ryzen 3 3300x CPU and an NVIDIA GeForce GTX 1660 Super, achieving a processing speed of **6 Hz**. However, further optimization is required to enable real-time execution.

Supervisors / Co-supervisors / Advisors: Prof. dr. ir. Eric Demeester
Ir. Yanming Wu

[1] “wenbowen123/BundleTrack: [IROS 2021] BundleTrack: 6D Pose Tracking for Novel Objects without Instance or Category-Level 3D Models.” https://github.com/wenbowen123/BundleTrack (accessed Jun. 03, 2023).