Autonomous Excavator System for Construction Automation

Ruitao Song, Samuel Ong, Liuwang Kang, Shiyu Jin, Yuan-Chih Peng, Zhenpeng He, Lingfeng Qian, Liangjun Zhang

Robotics and Autonomous Driving Lab (RAL), Baidu Research

Email: liangjunzhang@baidu.com

Robotics and Autonomous Driving Lab

ROBOTICS SCIENCE AND SYSTEMS

Highlights:

- Our latest advancements of the autonomous excavator system (AES) specifically designed for **earth moving** operations at **construction sites**.
- Currently, our AES demonstrates proficiency in executing three construction earth moving tasks**: truck loading, trenching, and unstructured terrain navigation.**
- A live demonstration where all three tasks were seamlessly completed consecutively **without human intervention**, highlighting its exceptional effectiveness and robustness. (Video of the live demonstration can be accessed via the QR code.)

INTRODUCTION

Construction

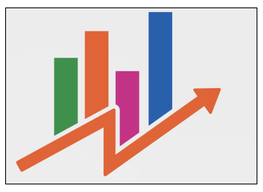
Search & Rescue

Industrial Production

Mining

Construction robots are beneficial across different operating environments.

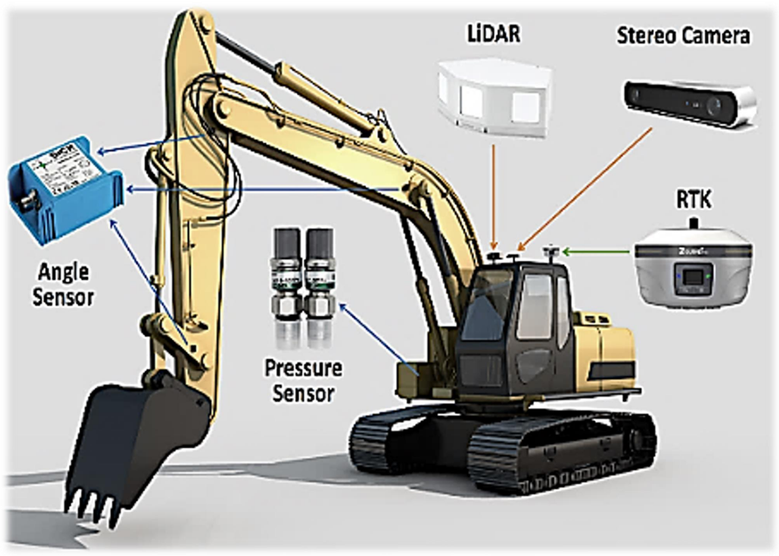
Improving Safety



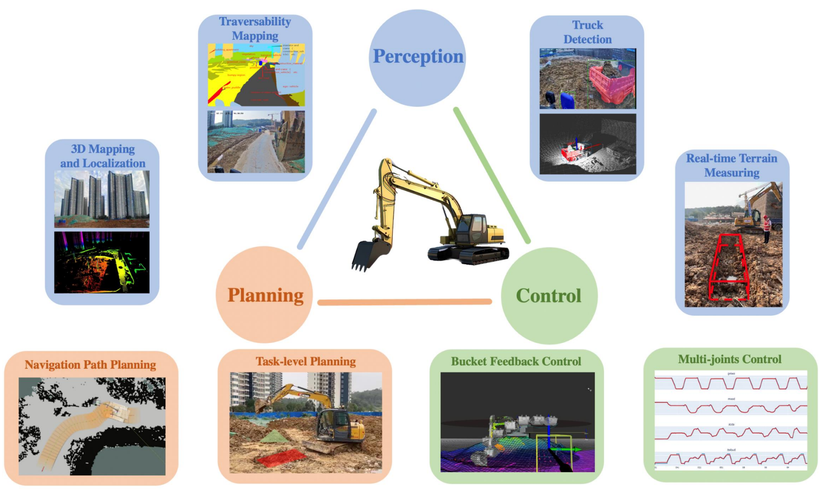
Increase Productivity

Reduce Cost

SYSTEM OVERVIEW



Our core algorithms primarily consist of three essential modules: perception, planning, and control.



EXPERIMENTS

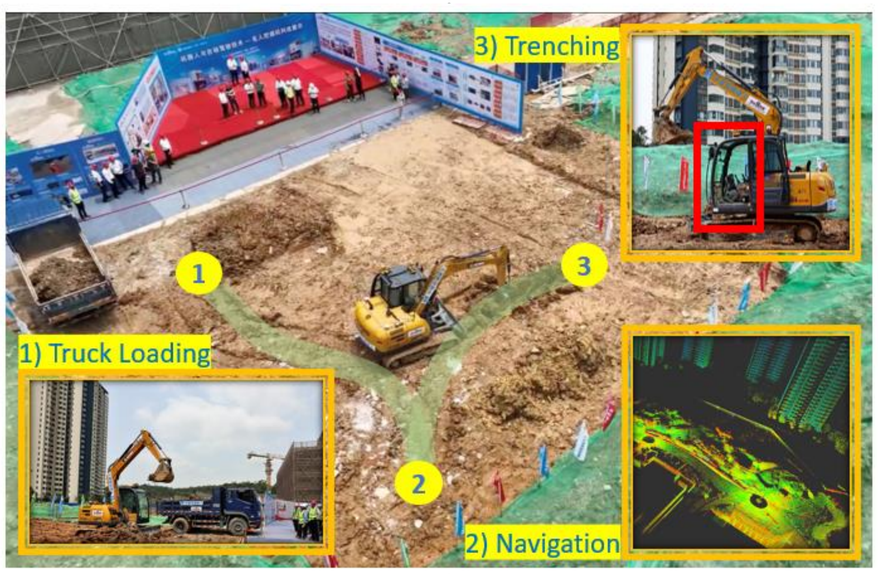
In April 2023, we successfully conducted a live demonstration in Guangzhou, China. Our autonomous excavator system performed these tasks seamlessly **without human intervention**:

1. truck loading, 2. terrain navigation, 3. trenching

Autonomous Truck Loading is a highly desirable feature in construction due to its repetitive and time-consuming nature.

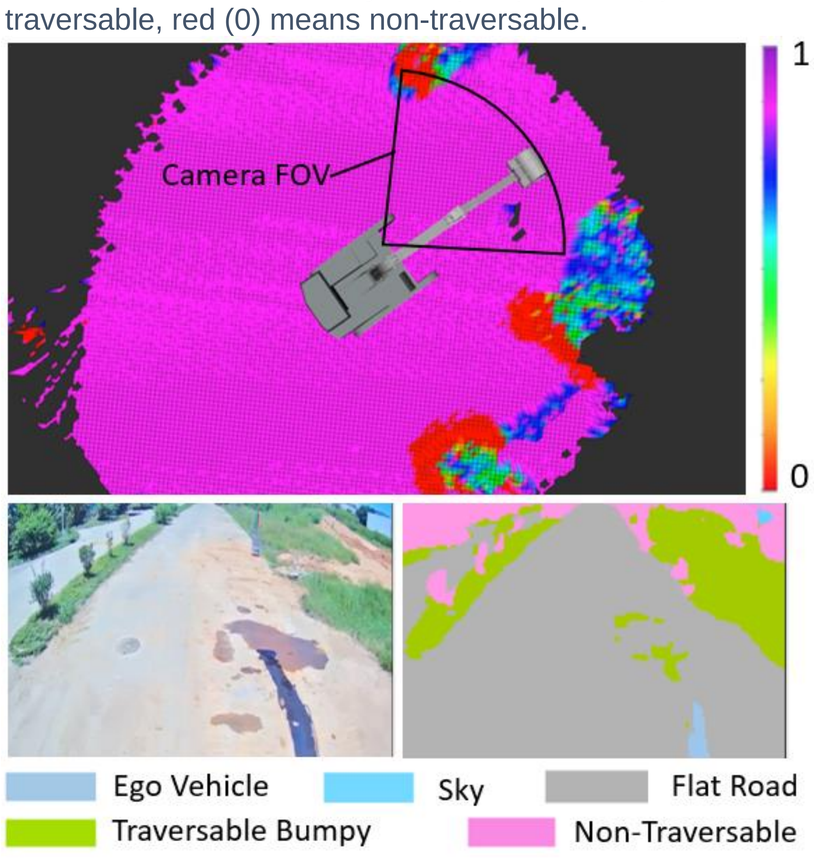
A 2m×3m×1m box is defined at a 45-degree angle by the excavator for digging.

The objective of this task is to accurately identify the designated digging area and the truck pose for dumping by utilizing the perception system.



Terrain Navigation, our navigation system allows the excavator to move autonomously and safely through rugged terrain while avoiding obstacles, detecting changes in the environment, and accurately positioning itself for digging or other tasks.

Semantic-geometric traversability mapping: Bottom-Left: camera image; Bottom-Right: segmentation result; Top: accumulated traversability map, purple (1) means traversable, red (0) means non-traversable.



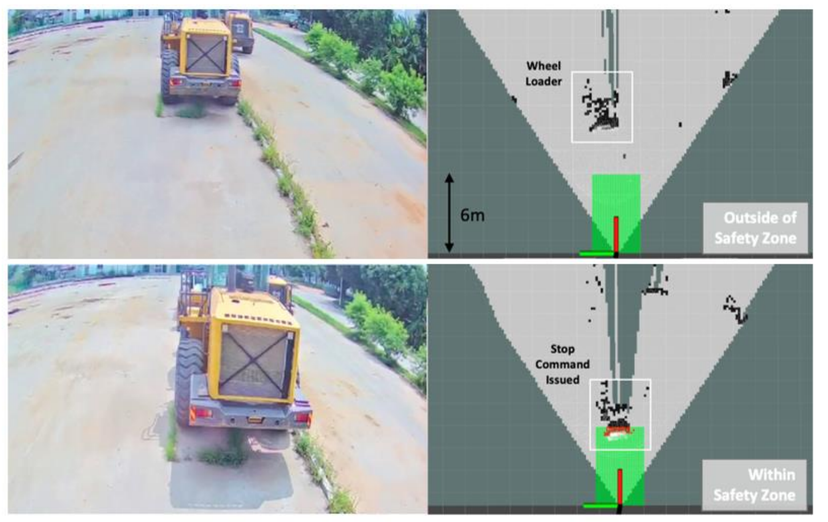
Excavator Trenching has a wide range of applications in construction and civil engineering projects, including the installation of underground utilities, excavation for drainage systems, landscaping, and road construction.

The objective of the task is to remove soil within a cuboid-shaped area. This can be accomplished by dividing the trench task into multiple sub-tasks along the length with the high-level task planner.

In the demo, a 1m × 1m × 6m area, with each sub-task being 1m × 1m × 2m. The trench task is divided into 5 sub-tasks, with an 1m overlap between adjacent sub-tasks.

The entire trench task, including the base movement, is completed in 11.78 minutes. The average depth error in the trench is 0.020 ± 0.101m.

Emergency Stop plays a crucial role in ensuring safe navigation on intricate and ever-changing terrain. It guarantees that the excavator will promptly execute a stop command upon detecting an obstacle that the navigation system has not identified.



REFERENCES & CONTACTS

Demo Video

Website