Outdoor Visual-SLAM for Mobile Walking Excavators

Real-time environment data acquisition to support the control of mobile walking excavators

Graduate

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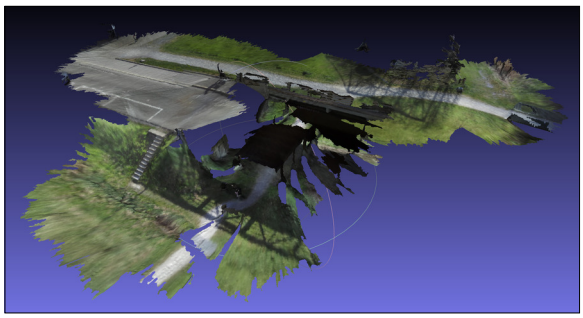
Initial Situation: Mobile walking excavators are used for operations in challenging terrain. Their complex joint mechanics make control demanding, as incorrect positioning can lead to dangerous tipping. The risk of tipping arises when the excavator's center of gravity lies outside its support points. A visual SLAM system is a computer technology that enables the mapping of the environment into a 3D map using camera images. The goal of this work was to examine the suitability of such a system. Based on visual SLAM data, further applications can subsequently be developed, including structural stability calculations.

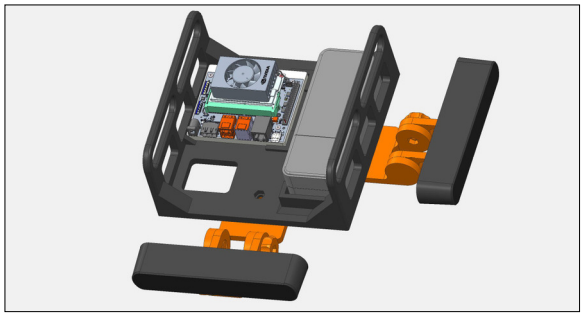
Approach / Technology: In this work, the technical foundations and requirements of a SLAM pipeline were examined. Various pipelines were evaluated based on criteria such as robustness, real-time capability and accuracy. The best systems, including RTAB-Map, ORB-SLAM and the ZED SDK, were implemented on an NVIDIA Jetson platform and qualitatively compared. The ZED SDK demonstrated the best suitability. The parameters of this pipeline were optimized using a design-of-experiments approach. For a larger field of view, multiple cameras are required and their positions must first be calibrated. An evaluation was conducted to determine how precisely the cameras could be calibrated using a dedicated program. In addition, a multi-camera system was tested that can merge multiple 3D maps. For this purpose, a program was developed that processes multiple camera inputs and captures only the nearby surroundings to reduce memory usage.

Result: The results show that the ZED SDK is suitable for supporting the control of walking excavators. The pipeline produces a solid 3D map in the form of a mesh, which can be further processed. Challenges remain with inaccuracies in the map over longer distances and the need for precise camera calibration. Future improvements could be achieved through more powerful hardware and the integration of GPS data.

Section of a mesh map
Own presentment



Test setup with camera
Own presentment



Kaiser S12 Mobile Walking Excavators
Own presentment

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Subject Area
Computational Engineering

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