MAS ISW Reading Reports

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05.12.2020

Contents

1 Reading Report: *Plant detection and mapping for agricultural robots using a 3D LIDAR sensor*

(Weiss & Biber, 2011)

Abstract

In this article, we discuss the advantages of MEMS based 3D LIDAR sensors over traditional approaches like vision or stereo vision in the domain of agricultural robotics and compare these kinds of sensors with typical 3D sensors used on mobile robots. Further, we present an application for such sensors. This application deals with the detection and segmentation of plants and ground, which is one important prerequisite to perform localization, mapping and navigation for autonomous agricultural robots. We show the discrimination of ground and plants as well as the mapping of the plants. Experiments conducted using the FX6 LIDAR by Nippon Signal were carried out in the simulation environment Gazebo, with artificial maize plants in the laboratory and on a small maize field. Our results show that the tested plants can be reliably detected and segmented from ground, despite the use of the low resolution FX6 sensor. Further, the plants can be localized with high accuracy.

Keywords

Individual plant detection, Plant mapping, 3D LIDAR sensor, Agricultural robotics

Questions

What are the motivations for this work?

A key problem in agricultural robots is to detect and map individual plants for several reasons, including navigation, individual reports and individual care. For a robust plant mapping it is needed to use reliable sensors and algorithms. Much research is done in solving this problem using 2D and 3D cameras but this paper on the other hand, works on detecting plants using low cost and low resolution 3D Lidar sensors.

What is the proposed solution?

The solution contains an algorithm for detecting individual plant in a row using a FX6 3D Lidar sensor. This sensor is still in development, the current version has a resolution of 29 by 59 pixel creating 15 frames per second. To detect the plant from the resulting point cloud, the algorithm first detects the ground plane and second creates cluster for each plants using a k,d tree and decides for each cluster only using the bounding box dimensions.

What is the work's evaluation of the solution?

The proposed algorithm works seemingly fast, and manages to identify in a single frame 60% of the plants and using multiple frames with tracking it scores an average detection accuracy of 80-90%. Further the average accuracy of the position detection is 3 centimeters. One problem occurring repeatedly is that the algorithm fails to differentiate between the next plants if they grow into each other and the cluster connect.

What is my analysis of the identified problem, idea and evaluation?

The idea to use a low cost 3D sensor is quite good because, as mentioned in the paper, it works independent from existing lighting and is robust against fog and dust - conditions which occur frequently in the real world. The algorithm uses only a bounding box of a cluster to determine the position of the plant. This approach works okay when every plant grows neatly far away from their neighbours but fails in messy real world conditions. Some aspects are great on the other hand, it has a fast runtime, for example. I think this given approach would work better on a row basis and maybe use offline compute power to identify the individual plants? Because measuring these plants is a repeated operation, one could leverage the result of a computational more expensive offline algorithm and map the online point cloud directly onto an existing map.

What are the contributions?

This main contribution is an evaluation of a low-cost 3D lidar scanner with an basic point clustering algorithm in real time. besides that they also showcase other approaches for the same problem using traditional 2D camera systems and different scanners.

What are the future directions of the research?

The future research will include using stronger machine learning algorithms for clustering and plant separation. They also want to work on a row detection basis.

What questions have I left?

My main concern was the quite simple simulation model on gazebo and i hope that they improve this.

What is my main take away from this paper?

It is possible to detect plants in real time using point clouds in the agricultural sector even with simple mathematical methods. The difference between a classical and those FX6 laser scanner is also interesting. I think plant detection like this is the way to go, by improving only the algorithm it should be possible soon to deploy at least field scouting robots in real world scenarios.

Summary

In depth paper for clustering point clouds into individual plants using a bounding box approach. Maths is explained nicely, can be used to build something similar.

Rating

4/5

2 Reading Report: *Agricultural robots for field operations: Concepts and components*

(Bechar & Vigneault, 2016)

Abstract

This review investigates the research effort, developments and innovation in agricultural robots for field operations, and the associated concepts, principles, limitations and gaps. Robots are highly complex, consisting of different subsystems that need to be integrated and correctly synchronised to perform tasks perfectly as a whole and successfully transfer the required information. Extensive research has been conducted on the application of robots and automation to a variety of field operations, and technical feasibility has been widely demonstrated. Agricultural robots for field operations must be able to operate in unstructured agricultural environments with the same quality of work achieved by cur- rent methods and means. To assimilate robotic systems, technologies must be developed to overcome continuously changing conditions and variability in produce and environ- ments. Intelligent systems are needed for successful task performance in such environ- ments. The robotic system must be cost-effective, while being inherently safe and reliabledhuman safety, and preservation of the environment, the crop and the machinery are mandatory. Despite much progress in recent years, in most cases the technology is not yet commercially available. Information-acquisition systems, including sensors, fusion algorithms and data analysis, need to be adjusted to the dynamic conditions of un- structured agricultural environments. Intensive research is needed on integrating human operators into the system control loop for increased system performance and reliability. System sizes should be reduced while improving the integration of all parts and com- ponents. For robots to perform in agricultural environments and execute agricultural tasks, research must focus on: fusing complementary sensors for adequate localisation and sensing abilities, developing simple manipulators for each agricultural task, devel- oping path planning, navigation and guidance algorithms suited to environments besides open fields and known a-priori, and integrating human operators in this complex and highly dynamic situation.

Keywords

Agricultural robots, Robotics, Field operations, Autonomous

Questions

What are the motivations for this work?

The main subject of this paper is to show the current development, ideas and problems in the field of agricultural robotics. This review paper explains first the background, then the economic feasibility and furthers goes into concepts, principles and components.

What is the proposed solution?

The paper concludes, that with current technologies the broad usage in commercial farming is not possible yet and proposes to focus research on a number of fields. Those fields include sensor fusion for better localisation, engineering of better simple manipulators and the development of specific path planning, navigation and guidance algorithms for agriculture.

What is the work's evaluation of the solution?

This question is not applicable.

What is my analysis of the identified problem, idea and evaluation?

The authors make a great job in displaying the current technologies and their limitations. With this knowledge it is easy to identify a subproblem to work on.

What are the contributions?

Several points come to the mind. Firstly they create an in-depth background needed to understand the need of automated systems in agriculture, but also explain why it is so hard to create such systems. They propose a categorization of robotic system after the structure of their environment and object of interest. Both can be either structured or unstructured. This categorization creates four different categories. First, a structured environment and a structured object: This is the industrial domain. Second, a strucutred environment and a unstructured object: the medial domain. Further there is the unstructured enviroment with a structured object: the military, space, underwater and mining domains. The last domain, unstructured in environment and object of interest is the agricultural domain.

The next contribution are guidelines under which circumstances a robot can be commercially successful. These guideline conclude that it is possible to start using robots even if the costs are the same as conventional methods if the work of the robots create more steady and predictable processes.

A big part of the review are categorization concepts, components and principles. These include Human-Robot-Systems versus Autonomous Robot Systems. In the component section the authors underline following topics: steering and mobility, sensing and self-localization, path planning and guidance and last but not least, manipulators and effectors.

What are the future directions of the research?

This question is not applicable.

What questions have I left?

Many questions, this paper is an excellent basis for further research.

What is my main take away from this paper?

One of the main problems is the highly dynamic environment and the need to react fast to unprecedented situations. This creates the question on how to define behavior in such a way to allow and strengthen the capabilities of improvisation.

Summary

In-depth review paper with some self citations but besides that it gives many new points to deepen my reseach.

Rating

5/5

3 Reading Report: *Agricultural robots—system analysis and economic feasibility*

(Pedersen, Fountas, Have, & Blackmore, 2006)

Abstract

This paper focuses on the economic feasibility of applying autonomous robotic vehicles compared to conventional systems in three different applications: robotic weeding in high value crops (particularly sugar beet), crop scouting in cereals and grass cutting on golf courses. The comparison was based on a systems analysis and an individual economic feasibility study for each of the three applications. The results showed that in all three scenarios, the robotic applications are more economically feasible than the conventional systems. The high cost of real time kinematics Global Positioning System (RTK-GPS) and the small

capacity of the vehicles are the main parameters that increase the cost of the robotic systems.

Keywords

Agricultural robots, Grass cutter, Autonomous vehicles, Economics, Feasibility study, Robotic weeding, Crop scouting

Questions

What are the motivations for this work?

The papers main focus lies on displaying the cost reduction possible by utilizing autonomous system for agriculture tasks. Most agricultural task can not use individual-plant-based solutions with conventional methods. By using robots and big data processing it will be possible to care for each plant individually. Taking care of an identified weed patch for example will need much less herbicides than spaying the whole field preemptively.

What is the proposed solution?

The authors propose solutions for using autonomous robots for field scouting - the identification and localisation of growing weeds -, intra-row and near-crop weeding and automated grass cutting.

What is the work‘s evaluation of the solution?

In all scenarios the authors showcase a reduction in primary and secondary costs in comparison to conventional methods.

Field scouting 20% cost reduction in labor and secondary benefits of the data because it is now possible to only deploy herbicides where needed.

Weeding Only by reducing the cost of the navigation system by half it is possible to save 12-21% or manuel costs. and reduction of herbicide use of 90%

Grass cutting Reduction of cost of 52% (but only when paying the gardener 27 Euro per hour, lol)

What is my analysis of the identified problem, idea and evaluation?

The usage of automated systems for growing crops is one of the key points in reducing the environmental footprint of large scale agriculture. The three analyzed areas are great entry points for deploying such systems. Especially the field scouting and the automated weeding are very interesting. For the evaluation the authors compared the costs of the components with average conventional costs witch is mostly reasonable, expect the estimated labor cost of the gardener of 27 Euros per hour for grass cutting.

What are the contributions?

The ideas of the authors in breaking down the cost of the robots into several components are very helpful to estimate economic costs of different system for this usage. The main contribution is this economic analysis which helped to spark more research in this direction.

What are the future directions of the research?

There will always be economic analyses for newer technology.

What questions have I left?

Because this paper is from 2006 I am eager to find a similar, more current breakdown.

What is my main take away from this paper?

That it is feasible to automate many agricultural tasks with almost existing technology.

Summary

Great in depth analysis but dated (2006), has good numbers for conventional cost estimates.

Rating

3/5

References

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