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Robots in Agriculture

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Abstract

Computer sensors and actuators such as global positioning systems, artificial vision and laser sensors have been gradually integrated into mobile robots for the purpose of configuring autonomous systems capable of moving operator activities during agricultural tasks. However, combining multiple electronic systems in one robot reduces its reliability and increases its cost. Hardware minimization, along with software minimization and ease of integration, are key to achieving viable robotic systems. A step forward in the application of automated equipment in agriculture is the use of robotic teams, where several specialized robots work together to complete one or more agricultural tasks. This article attempts to develop a system architecture for individual robots and robots that work as a team to improve reliability, reduce complexity and cost, and enable software integration from different developers. Several solutions are studied, ranging from fully distributed architectures to fully integrated architectures in which a central computer performs all the processes. This work also investigates different topologies for controlling robotic teams and driving other potential topologies. The architecture presented in this article is successfully applied in the RHEA team, which consists of three mobile ground units based on a commercial tractor chassis.

Keywords: Robotics System; Architecture; Global positioning systems; Competitiveness; Ergonomic

Introduction

Over the past twenty years, specialized sensors for artificial vision, global positioning systems, real-time kinematics, laser-based devices and inertial devices, hydraulic cylinder actuators, motors linear and rotary power, and electronics on computers, industrial PCs, and automatons have enabled the integration of many autonomous vehicles, especially agricultural robots [1]. These autonomous/semi-automatic systems provide precise positioning and guidance in the field of work, making them capable of performing precision agricultural tasks if equipped with farm tools or implements suitable profession. These tools with different rates of application of fertilizers or sprays, weeders and row seeders are also automated with the same sensors and actuators used in GPS autonomous vehicles. Artificial sense, rangefinder, etc. Therefore, when integrating a certain vehicle and a particular instrument, many sensors and/or actuators are duplicated and, worse yet, an external central computer must be used to coordinate the arrangement. sort:means and tools. The hardware minimization of the vehicle deployment system is essential to bring the agricultural machinery to market reliably, efficiently, and competitively. Therefore, designing a single controller for vehicles and tools will facilitate reliability, efficiency and competitiveness. Many research groups are developing specialized self-driving applications for agriculture that will work for years to come, but many others also aim to operate a group of vehicles under unified control. This is the emerging concept of robotic fleet, which represents a breakthrough in agriculture [2-5]. The theoretical basis regarding robotic fleets has been studied recently, but the first applications for agriculture are currently under development. To achieve this, the concept of minimizing redundant devices that coordinate different heterogeneous systems using an external central computer is very important.

To achieve a fleet of flexible, reliable, and maintainable autonomous mobile robots for agricultural tasks, the system architecture includes sensors, actuators, and computers that run algorithms for Vehicle navigation and deployment systems should be robust, simple, and modular. One of the most important tasks in designing a control setup is choosing the number and type of sensors, actuators, and computers. These components form the basis of architectural design and are difficult to reduce in number because cognitive and action processes cannot be avoided; however, these sensors and actuators are often managed by independent controllers, especially commercially available sensors such as LIDAR and vision systems. However, computers are flexible enough to share resources and improve system durability. In fully automated farming systems, multiple actions must be performed simultaneously to ensure efficient as well as safe enforcement, including the system, the crop field, and external factors, e.g. : human supervisor. Absolute or relative position on the ground, detection of obstacles and objects of interest, communication with external users or with other autonomous units, autonomous navigation or remote operation, and other applications. site-specific are some of these actions that together form a fully automated system. contain the system. agricultural system [6-10]. This system can be divided into two main subsystems: autonomous vehicles and autonomous tools. Automated vehicles, such as modified commercial tractors, specialized rigs, or small vehicles, guide the farming system through a crop field to perform a farming operation, such as harvesting. , hoe and weed control, will be done independently of the tool. Due to the complexity of the task, a large number of specialized sensors and actuators are required to complete a given task in a given environment.

Complication

To achieve a fully automated farming system, the two aforementioned common frameworks must be merged into a hardware and software architecture that shares the sensor system and planning method for both automatic instruction and dynamic and automated processing applications. This task should be done with the aim of reducing hardware capacity while maintaining required performance

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[11]. This architecture must be able to integrate different sensor and actuator systems developed by different research groups as well as different types of commercial devices. In addition, it must be flexible and incorporate several standard communication protocols common in high-tech agricultural applications. A modular architecture to provide convenient implementations for the interface between sensors and devices as well as a good organization of the perception, processing and operation of these types of systems is required due to Wide range of technologies available. So, first, this paper focuses on designing a suitable structure for autonomous mobile vehicles to work together as a team of robots on agricultural missions. Hardware reliability, true plug-and-play functionality, and programmability are essential for efficient farm vehicles and therefore a capable, yet modular, robotic fleet of robots. Scalability, ergonomics, maintainability and cost are also important to increase the number of real promising applications in agriculture.

The above basic characteristics are taken into account in the proposed configuration; however, other features are also discussed in the following sections whose main purpose is to provide agricultural machinery manufacturers with solutions for automating new developments, especially in mainstream agriculture. Precision, an emerging field that requires powerful and effective solutions [12,13].

The work presented in this article was carried out within the framework of the RHEA project, a project of the FP7 program funded by the European Commission. RHEA is focused on developing a new generation of means for efficient chemical and mechanical management of a wide range of crops to minimize the use of agricultural inputs to reduce environmental pollution while improving the quality of crops quality and safety of crops as well as reducing production costs. To this end, RHEA is working on (a) advanced cognitive systems to sense and identify crop health, including crop row sensors and (b) innovative drive systems to apply fertilizers and herbicides with precision as well as control or eliminate weeds directly. Additional research focuses on the development (c) of a group of small, secure, reconfigurable, heterogeneous, and complementary mobile units to ensure application of the processes across the entire field. Activity area This scientific activity will be complemented by technical developments in (d) a new communication and tracking system for the robotic team, (e) an improved simulation system and a graphical user interface plus operation, and (f) fuel cells source [14].

Autonomous agricultural system

The vehicle is the module responsible for ensuring the movement behavior of the absolute position and direction of the tool and must be adaptable to both the crop type and the type of crop intervention. Usually, the vehicle carries or pulls the tool and thus also supplies the necessary power to the tool. So the vehicle must include a mechanical three-point hook adapter to meet agricultural, generator and hydraulic pump standards. These specific subsystems are powered by commercial agricultural vehicles and therefore it is easier and more efficient to adapt a commercial agricultural tractor to configure an autonomous vehicle than it is to develop agricultural robots from scratch. It also allows developers to enhance system integration and testing while avoiding other time-consuming activities such as chassis design, manual assembly, vehicle testing and homology, for example. These modifications dramatically increase vehicle reliability by using long-tested components for the engine, brakes, steering and transmission, crankcase, and more. while reducing the time to be ready. The security, durability, and efficiency of the system must also be considered when structuring the entire autonomous system [15]. The final vehicle selected for the RHEA project was the 51 hp CNH Boomer-3050—37.3 KW, 1200 kg, with an empty and reconfigured cabin used to house computer equipment for identification and communication. , positioning, safety and transmission. In addition, some systems require the placement of specific elements outside the cabin: vision camera, laser, antenna and emergency fund.

Main controller

The main controller is responsible for controlling the vehicle correctly, coordinating vehicle actions and maintaining communication with the operator. In addition, the main controller integrates a large number of sub-systems. The integration of different systems based on different communication technologies, operating systems and programming languages leads to questions about the organization of hardware and software architecture, which can be centralized or distributed, open source or commercial development software, among others. These options have advantages and disadvantages that can be found in any technical literature on the subject. Distributed architecture is based on multiple computers running different applications on similar or different operating systems. The computers are connected by a communication network or point-to-point communication links exhibiting very well-known features as well as a few shortcomings derived from its maintenance cost in terms of updates and security, the number of different operating systems and programming languages to be handled, time-consuming management needs, and network delays in communicating data, which may impair the real-time features of the system. Apart from considering the advantages and limitations of both configurations, the optimum choice depends on the specific application, that is, the number of sensors; the number and type of peripherals; the number of different computers, including operating systems and languages used; the required computing power; and the real-time requirement, among other factors. This task is relatively easy to perform in a closed requirement system, that is, a system in which we know the exact number of subsystems and their features. However, in agriculture, the number of different system configurations, the available commercial devices, and custom-made equipment make the selection of the optimum configuration a difficult task, particularly due to the different operating systems and programming languages.

The best solution, as in other engineering fields, could be to use a hybrid architecture featuring centralized and distributed characteristics capable of integrating new systems when possible and permitting the connectivity of the complex system by using distribution features, such as Ethernet networks and a CAN bus, among others.

Results

To present the implementation of a working group of robots configured with the main controller proposed in this article, a series of evaluations were carried out in the field of actual testing within the framework. RHEA project. A number of tests and integrations have been conducted to positively evaluate the system's effectiveness and the ease of new integrations, organized as follows: both quantitative and qualitative results related to both hardware mitigation and software development mitigation in a single fully closed farming system; presents the results of a collision avoidance algorithm, allowing to evaluate the benefits of material reduction in a fleet of robots towards agriculture.

Further evaluation of the system was carried out by removing the mobile ground equipment controller responsible for guiding the vehicle and implementing the path tracking algorithms in the main controller. In this case, we evaluated the system's responsiveness to changes in vehicle trajectory and speed, as measured by the number of messages sent to control both the vehicle's speed and direction. Ignoring the vehicle's mechanical response and algorithmic orbital performance, using the original RHEA scheme, the main controller can send notifications of new orbits at frequencies between 6 and 10 Hz. Using the proposed architecture, the main controller can send notifications of new speed and direction reference values at 100 Hz. It is incorrect to compare these two values directly because the messages correspond to different levels of control. Therefore, a qualitative analysis must be performed. The original RHEA diagram defined the guidance system as a deliberate architecture in which trajectory planning was performed by the master controller based on a predefined mission and information from the system. awareness and GMUC implementation of this plan. The proposed architecture turns this configuration into a hybrid, where in critical scenarios, such as obstacle avoidance, row guidance, process safety, changeability Vehicle position and orientation are improved.

Conclusions

Robots and new technology have begun to improve conventional agricultural practices, such as increasing yields and reducing the use of chemicals that can have an impact on the environment. In addition, new robotic systems for application in agriculture are being developed to allow the integration of different technologies while allowing for modularity, flexibility and adaptability. This paper presents a structure so that agricultural vehicles can operate both automatically and in groups, i.e. simple, powerful and reliable. The generic scheme has favorable features for rapid deployment of new vehicle controllers and development/integration of advanced agricultural tools. Three examples are reported here: explosive sprayers, thermomechanical machines and air sprayers. The proposed architecture for centralizing the main controller and main sensor systems offers certain advantages for future sensor combinations. The integration of important sensors in autonomous agricultural applications, such as high-definition cameras and laser systems, allows information to be combined to improve the performance of the sensor system in terms of accuracy. Higher durability, and additional data and reduced hardware, increasing the speed of communication and information shared by different modules.

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