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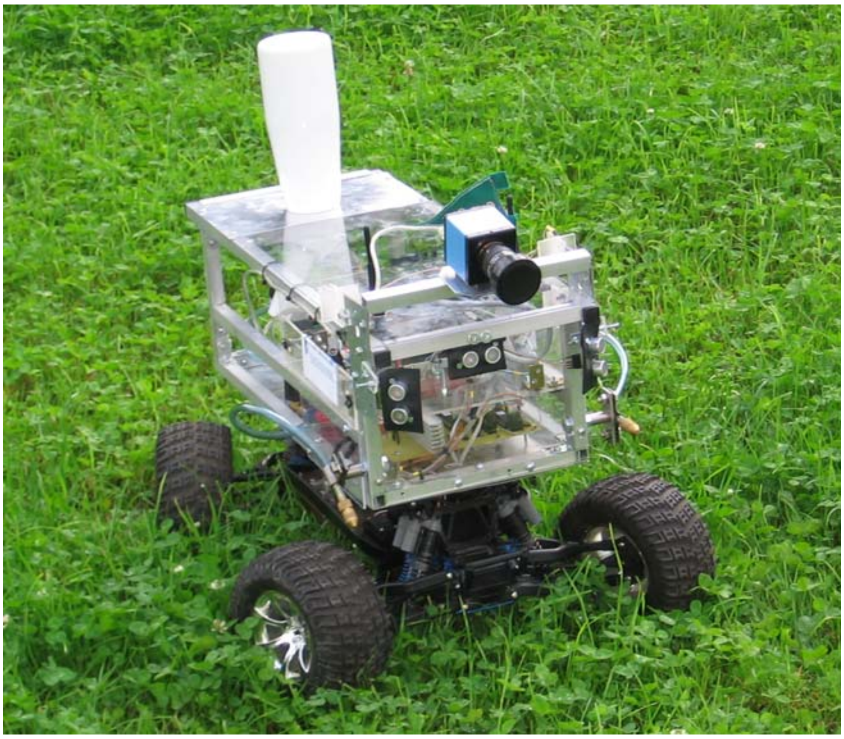
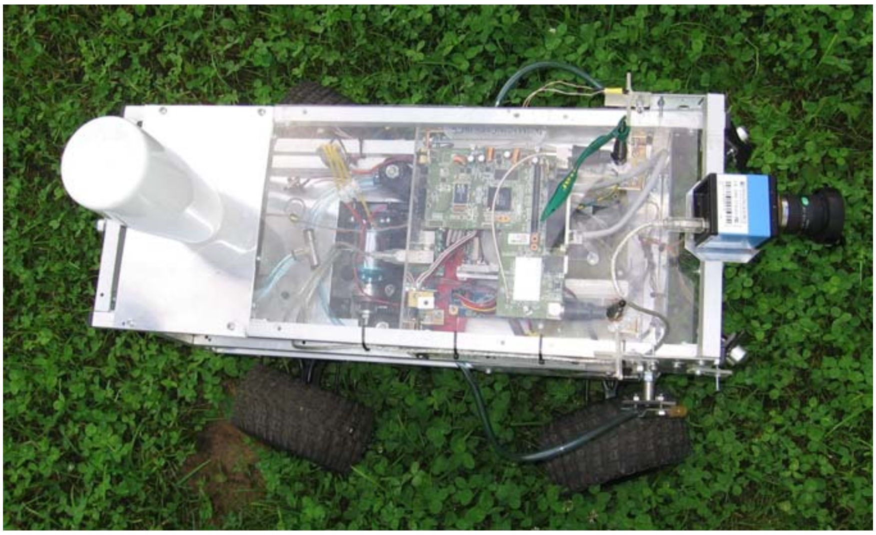
Abstract:

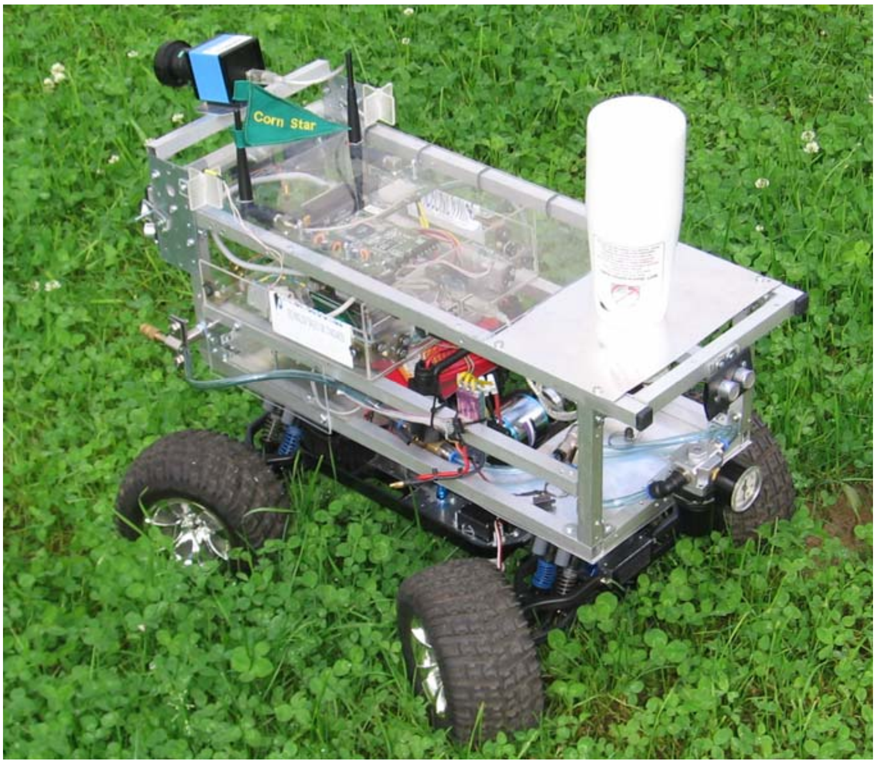
We present a small automated self oriented mobile platform, which could one day replace human labour on the fields, by doing the work quicker, with higher precision and lower costs. To achieve this goal we equipped the platform with ultrasonic sensors, high resolution digital camera and an onboard embedded computer. The embedded computer captures data from ultrasonic sensors and digital camera in real time and transmits them to off site workstation for further analysis. We tested the robot to detect simple objects, where several simulation runs proved promising successful rates.



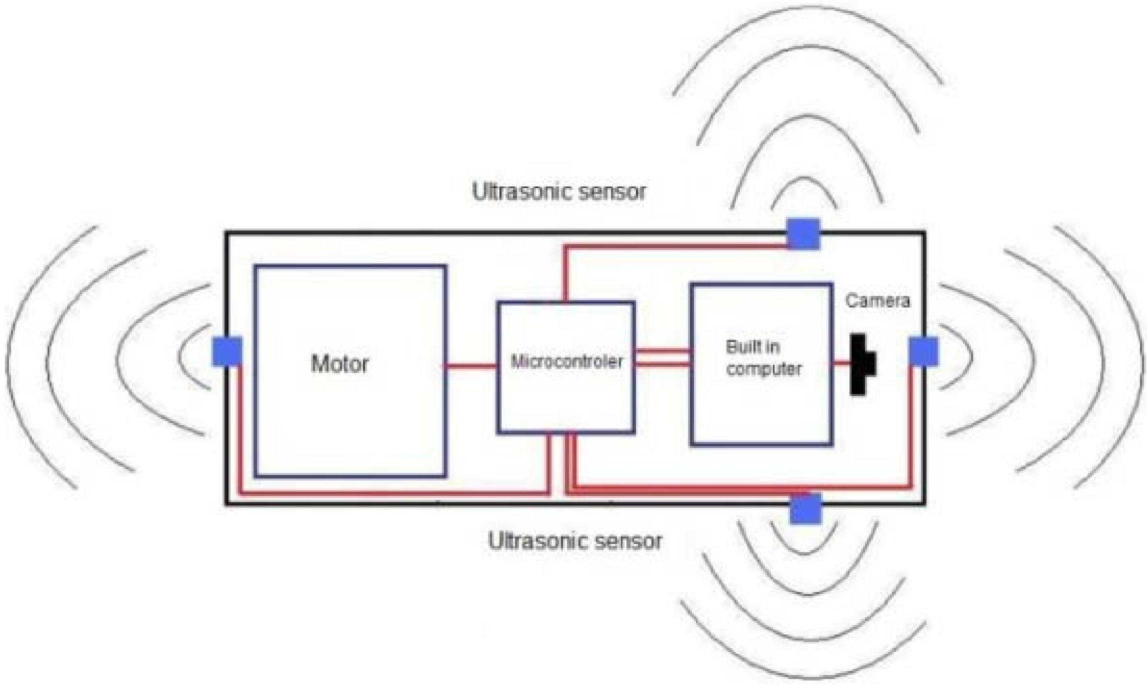
Detailed research information:

In the age of technological revolution agriculture will be one of the disciplines that will probably benefit most in the future. As big food producers relay on the use of heavy machinery, this is still not the case for middle and small farms, which can pose a potential food safety problem. If handled manually, food can transmit disease from person to person as well as serve as a growth medium for potentially harmful bacteria. Nevertheless, some work still demands manual labour that is time consuming, exhausting and expensive. The thought of introducing a small army of intelligent robots to do the job quicker and more accurate seems appealing, but we are not just there yet. For one, natural uncontrolled environment poses a challenge with its changing conditions. An overview on the subject showed that there are some potentially good solutions but the authors relay on specific conditions (like night time) or their solution is designed to work in controlled environments (green house) and some are simply too big or too heavy to be useful at this stage. We try to tackle the problem by introducing our own mobile agricultural platform.





Our platform consists of four crucial components. The first is an onboard embedded computer (x86 compatible, 1400 MIPS @ 15 W consumption) with high speed digital camera in a wireless connection (IEEE 802.11g). The second is a four-wheel drive that makes possible for platform to move around the rough terrain. The third are the ultrasonic sensors that help to keep track of the surroundings. And finally, the fourth part, the onboard reservoir and nozzles that spray the plants.



Microcontroller

The job of controlling the mobile platform is left to the microcontroller circuit that receives instructions from the embedded computer and acts according. It also consistently reads distance measurements from all four sensors and transmits the data to the embedded computer via serial (RS 232) connection.

Sensors

Distance measurements are captured with the help of four SRF04 ultrasonic sensors that can measure a distance of up to 3 meters, which was enough for all test scenarios. Distance measure from each sensor is captured four times a second.

The embedded computer

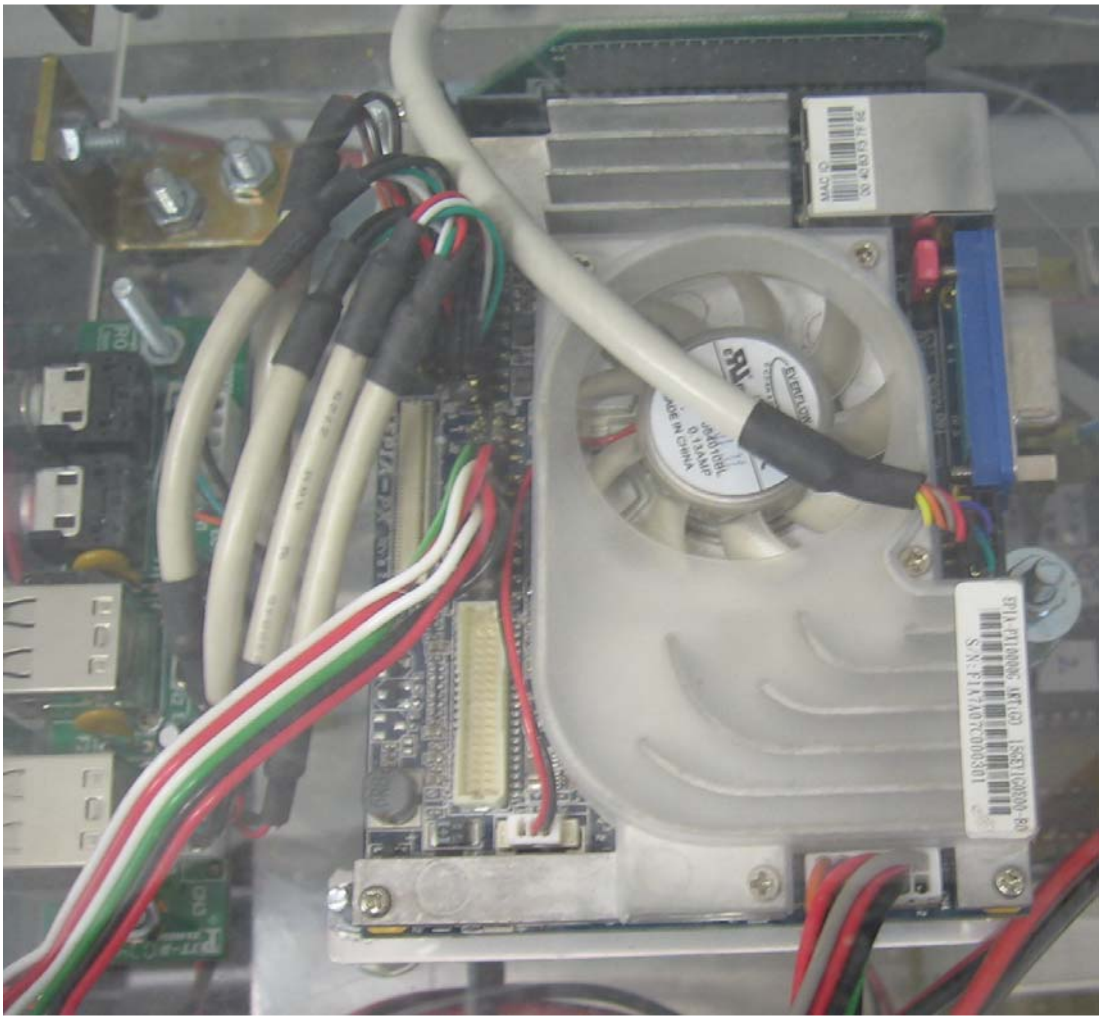
The embedded computer gathers all relevant data from onboard sensors and transmits them to off-field workstation. There the data is processed and a decision is made on how to control the platform (which direction to take, when the open the nozzles, speed adjustment, etc.). Of course most of the decision making algorithms could run on embedded computer, but are still located on the off-field workstation. The purpose behind this scenario is easy and rapid development of new algorithms as well as almost instant control of the platform in cases of emergency.

As the operating system for the embedded computer we have chosen and customized a version of the Linux operating system (Debian based). The first step we took was to remove all unnecessary software. As the second step, we compiled a custom 2.6.22 kernel according to the hardware specifications and finally, as the third step, we tuned the settings for the

TCP/UDP protocols to reserve more buffer space and to transmit small data chunks faster in effect minimizing the transmition delays.

Steering

In order to drive the mobile platform, we have chosen a high-performance brushless motor (X-power eco A4130-06BL). This is a three-phase motor so in order to use it, we have added an extra controller (x-power professional 70-3P BEC), which controls the coils of the motor. The controller automatically detects the number and type of batteries used. In our case we used Lithium batteries (LiPolice 5000mAh/2S 7,4V 75/100A) with two cells. The controller also controls the speed and rotation direction of the motor. Brushless motor speed is controlled with the help of pulse width modulation. At given (high enough) modulation the motor will run at constant speed consuming around 40 watts of power.



The steering algorithm

The algorithm can be divided into two sub-algorithms. The first analyses the data captured from distance sensors and steers the platform, while the second analyses the video stream captured by digital camera.

We have strategically placed ultrasonic sensors on all edges of the platform in order to capture distance measurements from all sides. In case distance from one side is smaller than the distance on the other side, the heading of the mobile platform is adjusted. We have also considered situations in which plant rows are not perfect and are missing a few plants. These cases can be detected via comparison with a predefined maximum distance from each edge.

When enouncing this kind of situations, the platform navigates only by capturing measurements from the other (fully planted) side and steers by minimizing distances from one size.

Computer vision part starts with decoding a compressed video stream. Then each frame from the stream is analyzed successively by detecting plants with predefined characteristics like colours, shapes and textures. In case such object is detected, the platform activates the nozzles and sprays detected objects.