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Applications of Stereovision in precision Agriculture

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ABSTRACT

With increasing in world population to over 10 billion, by the year 2050, growth in agricultural output needs to be continued. On the other hand use of chemical fertilizer, herbicides and pesticides for high performance in crop production in recent years made many issues such as environment pollution, decreasing in product quality and increasing in costs. Therefore, considering this, variable rate technology and autonomous vehicles application in precision agriculture is one of the main issues to be regarded noteworthy toimprove the efficiency. As most crops are cultivated in rows, animportant step towards this long-term goal is the development of a row-recognition system,which will allow a robot to accurately follow a row of plants.This research aimed to explain a field sensing system capable of performing threedimensional (3D) field mapping for measuring crop height and volume and detecting croprows in 3D for reliable tractor guidance using one tractor-mounted stereo-camera.

Keyword:
Stereo Vision,
Precision Agriculture,
Auto Navigation

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INTRODUCTION

With the predicted increase in world population to over 10 billion, by the year 2050, growth in agricultural output needs to be continued. Considering this, autonomous vehicles application in precision agriculture is one of the main issues to be regarded noteworthy to improve the efficiency(Mousazadeh H, 2013).

Increasing cost of chemicals and the soil pollution caused by the herbicide residuesask for alternative methods of crop protection. A potential way of reduction of chemicals is the use of precision techniques for various types of agricultural operations, so that the chemicals can be placed where they have an optimal effect with minimum quantity. Organic farming is not only a political goal; there is also a need from the market. More and more customers are asking for products that are organically grown. This has led to a problem for companies that need to increase their supplies of organically grown products to meet customer demands(Bjorn Astrand et al., 2005).

Crop growth condition monitoring and automated vehicle guidance are two major operations in mechanized precision agriculture. In recent years, commercial GPS-based guidance tractors and yield mapping systems have been made available by major agricultural machinery manufactures(MichioKise et al., 2008).

Steering agricultural machinery within rowed crop fields to perform various production tasks is a tedious job for producers. To solve this problem, automated machinery guidance systems have been developed to automatically steer the machinery following crop rows to perform the required operations. The basic requirements for an automated machinery guidance system include detecting the machinery position and orientation in related to crop rows in real time(M. Kise et al.,2005).

The exact performance of a system depends on input data accuracy and quality of system design and as long as the input is not correct and on time, any amount of system design would be accurate and robust, it will not have necessary efficiency(Dooji et al.,2004).

The role that information technology is playing in present day engineering applications has led to a growing interest in acquiring as much information as possible from available sensors, mainly with regard to localization and perception. In that stream of research, a methodology to generate 3D terrain maps was developed by combining information obtained with a compact stereo camera, a localization sensor and an inertial measurement unit(Francisco Rovira-Mas et al., 2008).

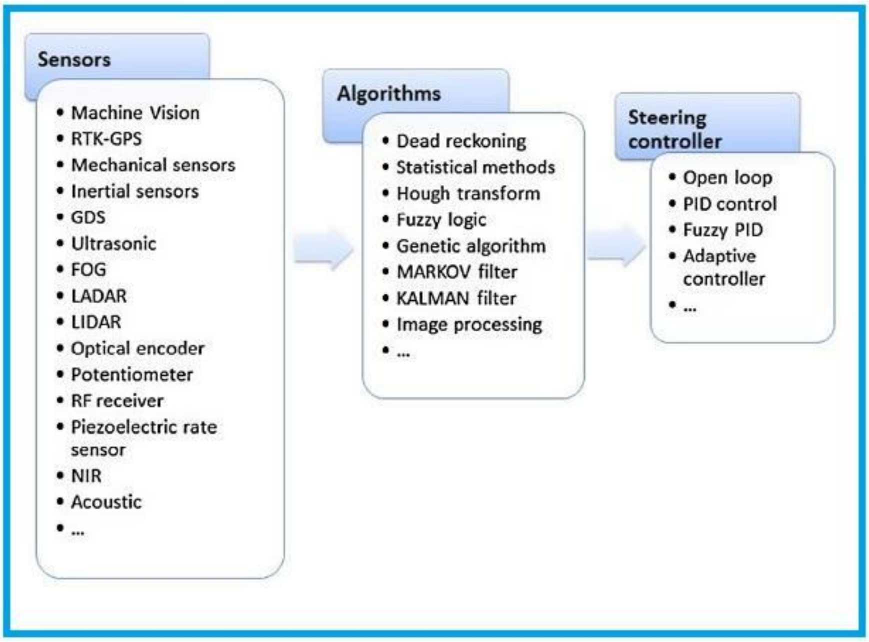

Fig. 1. Basic control diagram of autonomous vehicles

To design and increase the accuracy of systems are used from different sensors. One of the most common types of navigation sensors is the global positioning system (GPS) that the real-time kinematic-GPS (RTK-GPS) is more accurate types. As a machine vision system can detect a path in relation to crop rows, vision-based guidance can be used to guide machinery travelling between crop rows to perform field operations such as cultivating, chemical spraying, and harvesting. In a vision-based guidance system, crop row features are extracted from acquired field images to obtain a guidance direction. To obtain more complete field information, a stereovision system can provide a three-dimensional (3D) field image by combining two monocular field images taken from a binocular camera simultaneously(M. Kise et al., 2005).

The steer is controlled by a control algorithm as shown in the diagram of Fig. 1. According to figure,most popular sensors and algorithms and navigation and controlling systems that are used in different types of automation of agricultural vehicles are listed(Mousazadeh H, 2013).

In this article while describing performance of Stereo Vision, it would check several systems based on designed Stereo Vision by researchers and it gave a general view of designing and structure of system and creating algorithm to reader due to researchers.

1. Stereovision for autonavigation

In this research many papers are reviewed on stereovision-based systems. Approximately in all of them hardwaresare used and installed. The core element of the stereovision navigation system was an STH-MD1 stereovision camera. A personal computer was used as the navigation computer for stereovision image processing, tractor navigation parameters calculation, and steering signal generation. A microprocessor-based vehicle control unit (VCU), consisting of a single board computer and two motor driver integrated circuits (ICs), was developed to implement automatic steering. The auto-steering actuating system consisted of a solenoid driven proportional electrohydraulic direction control valve and a potentiometer-based wheel angle sensor for implementing closed-loop steering control. During auto-steering, the VCU received steering control signals from the navigation computer via a RS232 serial interface and generated pulse width modulation (PWM) signals to drive the electrohydraulic steering control. Figure 2 shows a machinery independent signal-flow diagram of a stereovision-based agricultural machinery navigation system.

Stereo Vision has many applications such as:Aerial Mapping, Forensics – Crime Scenes, Traffic Accidents, Mining – Mine face measurement,Civil Engineering – Structure monitoring, Collision Avoidance, Real-time performance needed, Depth accuracy critical, Manufacturing, Process control, Process monitoring, General Photogrammetry andAny non contact measurement.

Bases of Stereo Vision are derived from human visual system. There is a dominant eye in human visual system as interesting phenomenon. According to this phenomenon, one of human eyes acts exactly like reference camera (origin of coordinates) as the reference eye.

A single image has no depth information from object becouse that humans infer depth from ‘clues’ in the scene But These are ambiguous. Stereo vision systems take two images of a scene from different viewpoints that Usually referred to as left and right images. Left and right images are slightly different.Disparity is displacement of corresponding points from one image to the other. We can calculate depth of objects from the disparity.

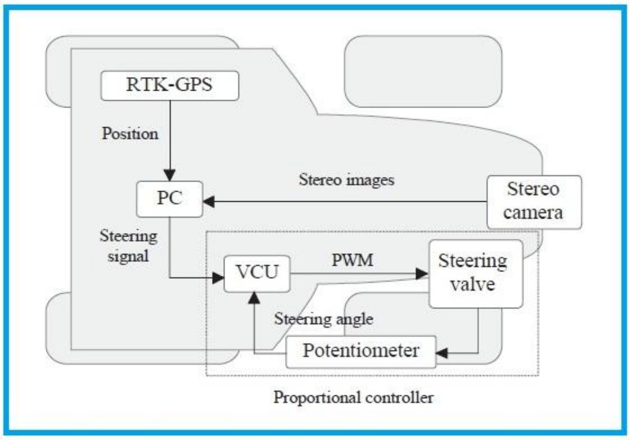

Fig. 2.Signal-flow diagram of the stereovision-based navigation system.

According to Fig. 3.OL andOR are the Optical centers of Left and Right cameras. In this stereo geometry, the distance between the centers of two lenses is defined as the baseline b, and the focal length of the lens pair is defined as f. The horizontal distance between an identified pixels in image L to the center of the image is defined as UL and in image R is defined as UR.

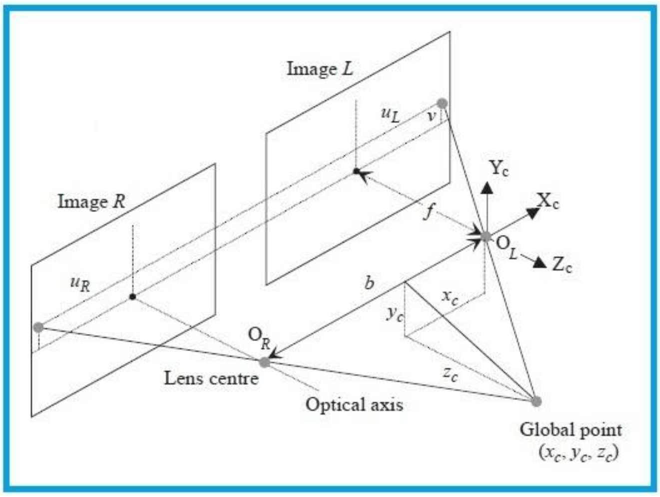

Fig. 3.Stereo geometry for stereo-image processing.

$$d = U_L - U_R \qquad (1)$$

One of the major objectives in stereovision image processing is to calculate the depth of the object ofinterest to the center of stereo camera lens, Zc. When both image planes are laid on the same plane and their horizontal axes are aligned, the equation 2 can be used to calculate the object depth.

$$Z_C = \frac{b * f}{d} \quad (2)$$

In Equation 2, the variable d can be defined as the disparity of a stereo image. Since the disparity of a point is inversely proportional to its depth, the disparity image provides a direct (but inverse) encoding of scene depth. Once the disparity is determined, the 3D location of a point (Xc, Yc, Zc) in the left camera coordinates can be obtained from Eq. 2 to 4.

$$x_c = -\frac{U_L}{f} * Z_c = -\frac{b * U_L}{d} \quad (3)$$

$$y_c = -\frac{v}{f} * Z_c = -\frac{b * v}{d} \quad (4)$$

2. Autonavigation by crop row detection

By this method, disparity and then three-dimensional(3D) place of all points would be counted continually and would be formed by some software which would be presented by stereo camera manufacturer companies to be prepared finally full map altitudinal of scene in each time of moving camera due to moving vehicle.

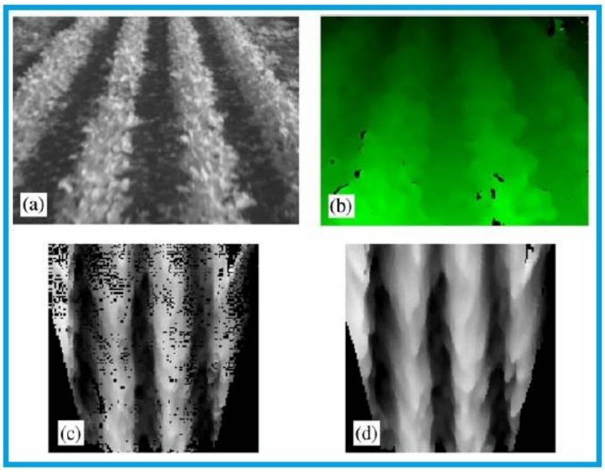

Fig. 4.Example of stereo-image processing.

Stereo-image processing is used to determine 3D locations of the scene points of the objects of interest from the obtained stereo image. Those 3D positions, determined by means of stereo image disparity computation, provide the base information to create an elevation map which uses a 2D array with varying intensity to indicate the height of the crop. Figure 4 shows an example of disparity computation and elevation map creation based on an actual soya bean field scene.

As shown in Fig. 4(a), the original field scene image represents the soya bean rows with crop height approximately 0.4m and row spacing of 0.75 m. The pixels in the original image represent some recognizable features of the field scene. The disparity map of an acquired stereo image [Fig. 4(b)] is computed by finding the corresponding points of a scene in both the left andright images. After converting the disparity map to 3D points in the camera coordinates, those 3D points were then transformed to elevation values at the corresponding locations in the vehicle coordinates as discussed previously.

Since the crop is always elevated from the soil, the pixels of an elevation map occupied by a crop must indicate larger values than the pixels occupied by the soil [Fig. 4(c)]. This conversion process (from disparity to elevation map) decreases the computational load by reducing the number of pixels from 320 by 240 points in a disparity image to 150 by 150 points for constructing a 3D elevation map. Figure 4(d) shows a filtered elevation map processed using a 1 by 3 median filter. The resulting map indicates that the developed spatial median filter could effectively fill the blank pixels with reasonable estimates and result in a smooth elevation map for further processing.

Figure 5 illustrates the information flow of the algorithm: it employed a three-step process of stereo-image processing, elevation map creation and navigation point determination in searching for a row tracking solution accurately and reliably from a stereo images.

The first step was stereo image acquisition and processing that computes the disparity image to obtain 3D information of the field scene. The second process is to make altitudinal map which involved in transferring camera to coordinates of the vehicle, is to create altitudinal map from object and filtration. The third and final process of diagram which is directing and navigation of vehicle, involved in determination of points navigation, calculate the optimal and ideal steering angle and sending steering signal. According to figure, if entire processes

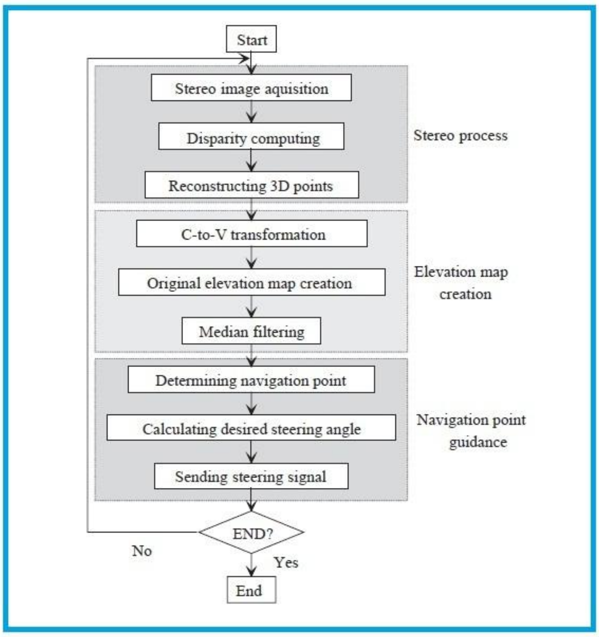

Fig. 5.Flowchart of stereovision-based systems algorithm.

(from taking photo to sending steering signal) would be implemented correctly. Vehicle would be directed and controlled without any damages to row products in farm and would be done by desired agricultural operations.

3. Conclusion

Research on agricultural vehicles automation is started from last century and is accelerated recently. In this research, some papers based on Stereo Vision are reviewed. Specially these researches focused on investigated the fundamental technologyfor a stereovision-based agricultural machinerycrop-row tracking navigation system. A crop-rowdetecting method, consisting of a stereo-image, processingmodule, a crop elevation map creating module anda navigation point searching module, has been illustrated. Based on the obtained disparity image, a three-dimensional(3D) crop elevation map could be created toprovide reliable and accurate tractor navigation informationfor crop-row tracking. This navigation systemcan effectively navigate a tractor following crop rows ina weedy field. Validating theapplicability of the developed system in detectingvarious types of crops and/or at different growing stagesis an interesting challenge for further investigation.Although obstacle avoidance and end row of turning are challenges that are merit of more consideration, in this research different techniques that are applied for navigation and path detection are considered. Finally it would be concluded although many developments in agricultural automation using different techniques and algorithms are obtained especially in recent years, more works are required to acquire farmer’s consensus about autonomous vehicles.

References

Bjorn Astrand, Albert-Jan Baerveldt. 200. A vision based row-following system for agricultural field machinery. Mechatronics 15, 251–269.

Dooji. B, Joharian. S, Rahimi. A. 2004. Using of Stereovision Systems in Robots Navigation and Surveying.3rd Seminar of Daneshpazhoohan e javan.

Francisco Rovira-Mas, Qin Zhang, John F. Reid. 2008. Stereo vision three-dimensional terrain maps for precision agriculture. Computers and electronics in agriculture 60, 133–143.

M. Kise; Q. Zhang; F. Rovira Mas. 2005. A Stereovision-based Crop Row Detection Method for Tractor-automated Guidance. Biosystems Engineering. 90 (4), 357–367.

MichioKise, Qin Zhang. 2008. Development of a stereovision sensing system for 3D crop row structure mapping and tractor guidance. biosystems engineering 101, 191–198.

Mousazadeh, Hossein. 2013. A technical review on navigation systems of agricultural autonomous off-road vehicles, Journal of Terramechanics. 50, 211–232.