International Journal of Multimedia and Ubiquitous Engineering
Vol.11, No.7 (2016), pp.57-68
http://dx.doi.org/10.14257/ijmue.2016.11.7.06

Research Progress of Visual Inspection of Tray Seedling and the System of Automatic Transplanting

Dongmei Pei [1], Fanjun Meng[1] and HaiLong Wang[2]

[1]*Computer and Information Engineering College, Inner Mongolia Normal University, Hohhot, China*
[2]*College of Network Technology Inner Mongolia Normal University, Hohhot, China*
ciecpdm@imnu.edu.cn

Abstract

As a kind of modern technology of growing seedling, Tray seedling is efficient with little plant diseases and insect pests, and save labors, which make it develop rapidly in domestic. When growing seedlings, there are not only holes that are not germinant or missed, but also inferior seedlings, which lead to leakage of planting and empty of planting during follow-up mechanized transplanting. In order to utilize each area of holes and seedbeds, holes without seedlings need to be transplanted filling the gaps with seedlings. The paper introduces research of visual inspection of tray seedling and the system of automatic transplanting domestic and overseas, explores the research progress of automatic transplanting system from four aspects, which are technic of visual inspection, end effector, control system and route optimization. The paper proposes existing problems and development of domestic visual inspection and automatic transplanting system, which offers references for follow-up study and marketing application.

Keywords*: tray seedlings; transplanting machine; end effector; control system; route optimization*

1. Introduction

In 1960s, US grew seedlings using vegetables in advance, and factory-like seedling growing was popularized to apply extensively because of its advantages. Traditional ways of growing seedlings were replaced by factory-like seedling growing in some developed countries such Holland and Japan. After it was brought in China in the middle of 1980s, technical workers through out of China explored moderate system of tray seedling for our country positively and got a good effect.

Seedling rate is between 80%~95% [1-2] in factory-like tray seedling, however, there are not only holes that are not germinant or missed, but also inferior seedlings, which lead to leakage of planting and empty of planting during follow-up mechanized transplanting, so getting rid of unhealthy seedlings and filling seedlings should be added before leaving factory. Using eyes in traditional process of filling seedlings could finish this work, but an intelligent recognition based on machine vision technology will replace eyes in the facility of automatic transplanting. Tray seedlings are put into the system of filling and transplanting robot [3]; end effector takes out healthy seedlings from transplanting tray and seeds into the tray where unhealthy seedlings are removed after visual inspection. [4-6]

Traditional artificial transplanting is inefficient and needs plenty of labor. As the important facility in the factory-like growing, automatic transplanting system is very important on improving efficiency. Based on more and more application of visual technic

ISSN: 1975-0080 IJMUE

on automatic transplanting system, domestic scholars begin to inventively research technics of transplanting robot in greenhouse.

2. Current Research Situation

Mechanized visualization is the most popular research topic in the area of artificial intelligence and it mainly uses computer to imitate the visual function of people, take information from outside pictures and order of pictures to deal with to understand and finally is used to inspect, measure and control. The basic theory of mechanized visualization is to transfer light to electronic signal through electricity, and then analyze the object through different kinds of imaging technology to select useful information to output [7].

Countries in Europe and America think highly of technic research and they are first to study recognition of healthy seedlings using visual technic. In 1994, Rutgers, The State University of New JerseyTai and other researchers brought mechanized visual technic into intelligent system to transplanting, fix the position of seedling hole and specs of tray by using video singly and irradiate the tray using strip laser. According to the features of strip imaging, they calculate the depth date of hole to control precisely [8]; Albertus and other researchers invent a set of automatic seedling transplanting machine with special visual recognition system and the function of filling seedlings and transmitting [9], and the machine can transfer multiple trays. Japan is always the country with high technology and abundant economy and its correlation technique of facility agriculture is highly developed. Research of discern for healthy seedlings based on visual technique has always been the leading position all over the world [10]. For example, TsukaYukinosuke researched on the device that could fill healthy seedlings by eliminating soil by suction device [11], which camera or photoelectric sensor cannot achieve. Jin jida studied on the device, which could inspect unhealthy seedlings and the area that cannot germinate in the whole tray by allocating a CCD camera on the end of robots hands and finally transplant healthy seedlings [12]. Japanese Science and Technology Corporation and Mitsubishi Machinery Company invented the seedlings separation device, which could keep separated seedlings immobile relatively but make CCD camera move. The machine can get rid of the damage of seedlings, which results from crack of soil and separate seedlings highly precisely. This invention distinguishes the quality of seedlings from images of divisional seedlings and removes bad ones [13].

Overall, transmitting assembling lines in greenhouses abroad are more than domestic and more automatic than domestic. However, the set of intelligent transmitting device is huge, which is suitable to big area of factory-like producing but difficult to satisfy small scale producing in factory-like agriculture in our country. The universality of greenhouse abroad is not good, the structure and control are complicated, and the auxiliary facility of transmitting cannot match the technique of growing seedlings in our country. The price of it is also beyond the capability of purchasing of small and medium business in our country.

As the technique of factory-like growing seedlings and facility agriculture are brought in and developed, the need for technique of filling and transmitting tray-seedlings by visual technique is increasing. Some colleges and universities begin to develop relative technique and prototype. Xiaoguang Chen and other researchers study on image processing techniques in the application of vegetables farming, extract the area of stem leaf, and accurately discern the contour line of vegetable seedlings and the coordinates of positions, which can achieve necessary information for automatic transplanting [14]. Agricultural mechanized research laboratory in Beijing invented a kind of mechanized visual inspective system, which could discern unhealthy seedlings intelligently according to characteristics of different seedlings during automatic transplanting. In the transplanting machine, the platform of visual system is established by using video camera, image capture card and image processor. Through certain calculation and analyzing bad seedlings automatically, positions of bad seedlings can be sent to processor. The processor outputs demands to remove unhealthy seedlings [15]. Nanjing University of Agriculture research a set of mechanized visual system, which is used to calculate area of tray seedling, inspection of empty or weak seedlings and calculation of seedlings took out by mechanized hands during the work of tray-seedlings transplanting automatically. The system integrates transplanting manipulator and transmitting device of tray seedlings conveniently to remove empty and weak seedlings [16].

In conclusion, lately in our country, factory-like growing seedlings develop rapidly. A lot of research laboratories start research and development of tray seedling visual inspective technique, but there will be many problems to be dealt with to achieve application of industrialization. Aiming at calculation of discerning different forms of seedlings and developing of reliable holder with zero damage, achieving route optimization in process, keeping high efficiency of control system is the key technique for separation of each seedling and transplanting effectively.

3. Research and Development of Key Technique

3.1. Visual Inspective Technique

Individual location and separation accuracy depends on the position and quality for intelligent tranplanters provided by recognition of seedlings characteristics. As for inaccurate location and low accuracy because of difference of trays, errors of positions by people and lack of depth data during early seedlings transplanting, scholars at home and abroad explore the visual inspective technique.

In 2003, Mizuochi and other researches use machine visual technique to deal with the problem of lack of seedlings, ill seedlings and abnormal seedlings. They also fix threshold value to achieve separation of cotyledon and vermiculite through analyzing colorful difference of G channel image of tray seedlings. They discern normal seedlings according to perimeter and circularity, which could achieve the elimination of ill and abnormal seedlings [17].

In 2007, Ye Ren and other researchers studied on recognition and position inspection of tomato seedlings based on machine visual technique. Conversion of color characteristics, which is suitable for image separation, is assured by research of different linear conversion of RGB. Put forward seedling plants From the background of, and then USES the simply connected domain analysis algorithm to extract soil hole of each seedling leaf area, and according to the characteristics of classifying seedlings, determine suitable for transplanting seedlings, and record the center position of the soil hole suitable for transplanting seedlings [18].

In 2009, Guoxiang Sun put forward a kind of measurement method to hole tray seedling leaf area based on image processing, use visual image system of visual tray to collect image of tray, according to RGB color separation of grey value theory, segment background using the 2 g - R - B color feature parameters, find the best image segmentation threshold through iterative method, calculate leaf area according to the distribution of blade pixel ratio. By induction, the image processing mainly contains segmentation of hole tray and transmission belt background, segmentation of seedlings and background, extraction of hole tray frame, extraction of feature parameter, identification of devoid seedlings and ill seedlings, and its processing flow is shown in Figure 3.1 [19]

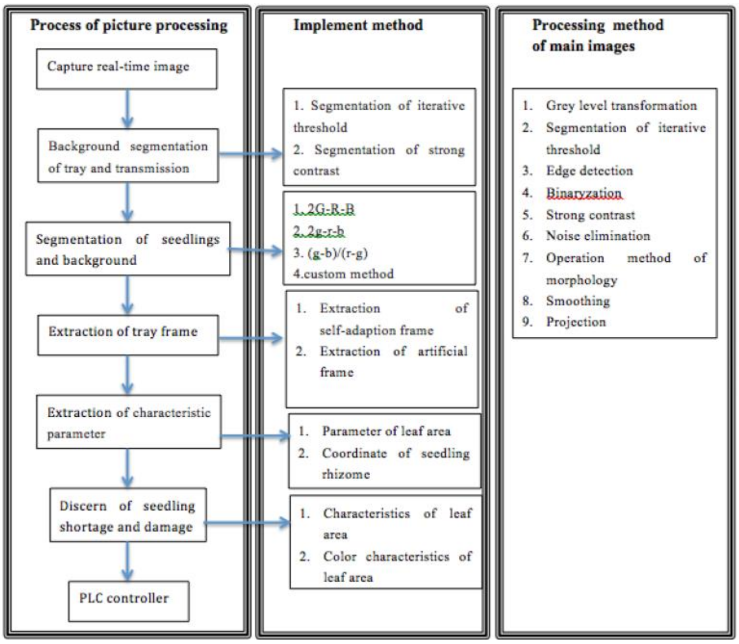
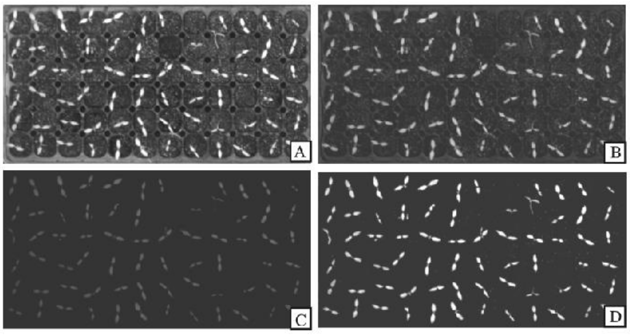


Figure 3.1. Flowchart of Image Processing

In 2012, Hu Fei devised a set of machine vision system, which is used for measuring the seedlings leaf area in soil hole in a real-time, determining whether it is suitable for transplanting and determining seedling fetching position which is suitable for transplanting. The test used CCD digital camera to collect images of tomato seedlings and converted to gray image, which optimized the gray image acquired by comparing the different gray scale factor to the effect of the processing. It is best in 1.8 G - 1.5 R - 1.8 B to process images optimally as shown in Figure 3.2.



A. 2 g - R - B Factor; B. 1.8 G - R - 1.5 B Factor; C. G - R - B Factor; D. 1.8 G - 1.5 R - 1.8 B Factor

Figure 3.2. Gray Image of Tray Tomato Seedling Processing in Different Gray Scale

In 2013, Tong, studies a set of machine vision system for seedling growth test in the port operation of automatic seedling move, using the watershed algorithm to get effective seedling traits, as shown in Figure 3.3 [20]. Through the different linear transformation research of three components, R, G, B, they determine the color characteristics of the image segmentation transformation. From seedling plants put forward the background, the perimeter of each seedling leaf area and leaf are extracted from the soil hole, and they classify seedlings according to the this characteristic to seedlings that are suitable for transplanting, and record the center position of the soil hole that is suitable to transplant.

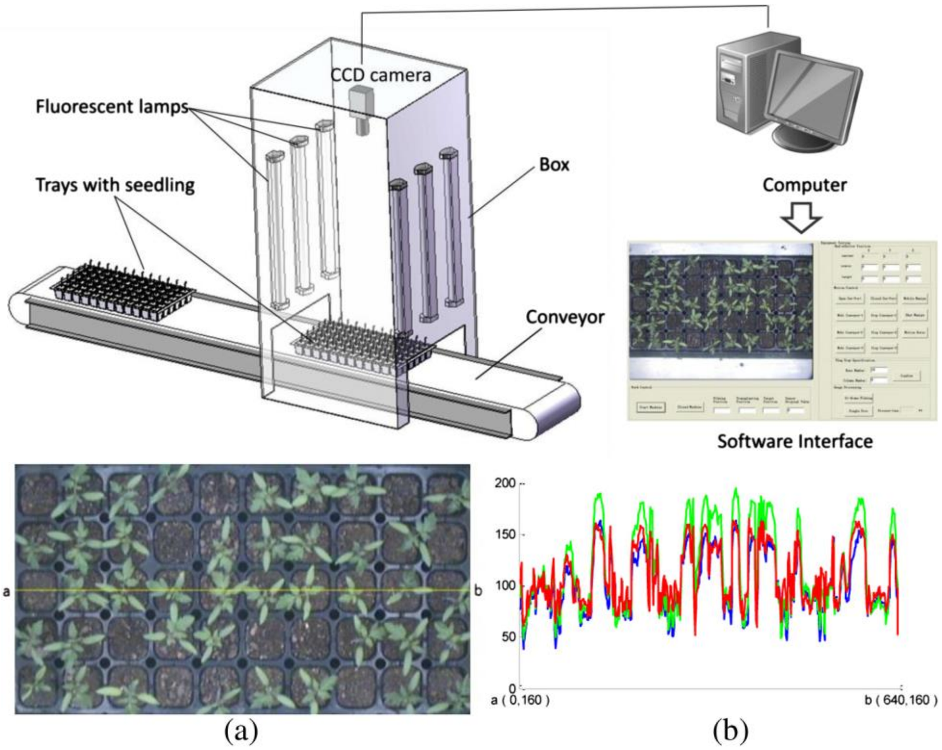


Figure 3.3. Visual System of Automatic Transplanting Machine

After obtaining growth state of seedlings and the information of soil hole center location effectively, depth of the matrix information needs to further understood the to provide the basis for intelligent transplanting. Yang Yang uses registration of color and depth of the images to detect hole tray contour from color images, and achieves the segmentation of soil hole tray in the depth image; makes use of depth image after segmentation to generate 3 d point cloud of each soil hole, calculates the normal vector at every point combining the nearest neighbor algorithm and the principal component analysis algorithm, and obtains the depth of the matrix based on the normal vector to achieve the segmentation of the soil hole wall and ground substance on the bottom of the hole to get the depth of ground substance[21].

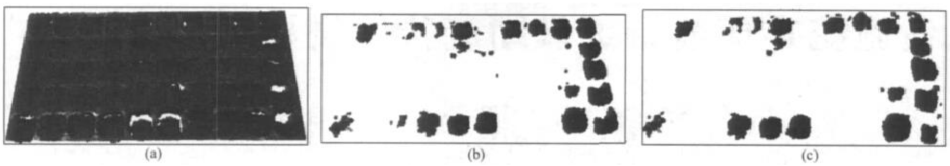


Figure 3.4. Each Point Cloud in the Detection Process of Substrate Depth

Through morphology operations such as corrosion expansion, image color information and the method of gray level threshold segmentation algorithm are used in visual detection technology, to get the area of seedlings and the plate frame of seedlings, and get seedling growth status to judge the lack of seedlings, and finally calculate coordinates of position of holes lack of seedlings and obtain the depth information of the substance, which could provide data for subsequent institutions of filling the gaps with seedlings. In the process, factors such as leaf overlap, cross, and deformation will lead to a larger error, so reduce the error by optimizing the image processing algorithm and scheme of grasping by hand in practical application.

3.2. End Actuator

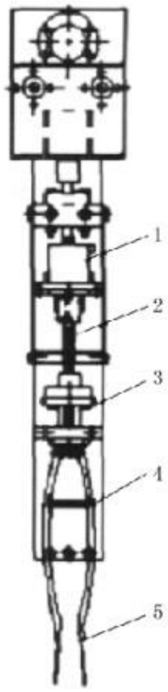
Then end actuator of automatic transplanting system is the medium of transplanting robot and seedling dish. It has to complete actions including fetching, maintaining, inserting and releasing. Because of different shape characteristics of seedlings and random distribution of cotyledon, damage to leaf, stem and cotyledon should be prevented in the process of the end executor, and at the same time, end actuator and seedlings can be separated fast and effectively when transplanting seedling. As a result, reliable nondestructive clamping in the process of transplanting by end actuator is one of the key technologies of intelligent transplanting machine.

Abroad early end actuators of taking seedlings mainly used mechanical function of scheduled with methods of seedling identification, for example, they identify whether there is a seedling and the judgment of seedling size, *etc.* In 1991, Yang and others developed telescopic pot seedling transplanting clamping claw. Retractable needle finger in the sleeve digs into seedling root substrate for clamping; finishes releasing by returning the finger, which overcame the fault, which well-formed fingers is not easy to fall off seedling, and it uses capacitive sensors to test whether there exists seedling [22]. In 1994, a well-formed pot seedling transplanting clamping claw developed by Kutz and others is structured by air-driven claw, photoelectric sensor and water injection nozzle, and a 0.635 mm steel wire finger is installed at the end of the air-driven claw. There is a pair of correlation of photoelectric sensors to detect whether there exists seedlings between fingers, and if there is no seedling, detect seedlings from the next hole. Installing pressure flow nozzle above fingers and spraying water to seedling root when planting is good to the seedling falling from hand claw, and washing the clamping fingers at the same time. The claw can be used to transplant seedling at 30 ~ 60 mm high and the success rate is more than 94% [23]. In 2001, Ryu and others designed an end executor of taking seedlings by manipulator. Initially, terminal actuators rotate to the position above seedlings; during working, move the end actuator down to seedling root area and clamp seedlings, and then move seedlings upward to remove them from the tray quickly [24]. Although the structure is complex, but directly grabbing seedling is helpful to reduce damage to tray seedlings and increase the survival rate after planting, it is good every kinds of adaptability of seedlings. In 2002, Choi and others developed a new type of vegetable seedling transplanting machine, which is compounded by the trajectory generator, finger and hand drive. The trajectory generator is a mechanism made by a fixed slot, an active connecting rod, a follower of connecting rod and a slider five-bar. When conducting an experimenting by using 23 days of vegetable seedlings, the transplanting machine can transplant 30 strains seedlings per minute at the success rate of 97% [25].

It is more and more precise to control end executor currently, and it has become a trend of electromechanical liquid fusion. Guoxiang Sun designed an end executor of tray seedlings transplanting machine [26]. As shown in Figure 3.5, according to results from the PC software image processing, obtain occasion information of transplanting disc and purpose plate, calculate the mobile distance of mechanical from left to right, and send corresponding amount of pulse to achieve precise mobile positioning when mechanical end is in screw.

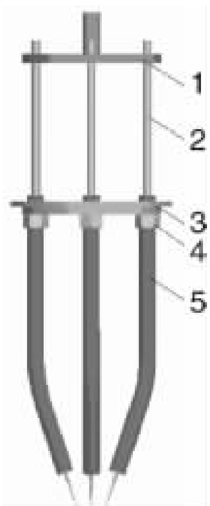
The wedge will screw rotation movement into linear movement. When moving downward, the wedge above open mechanical fingers and mechanical fingers grasp action; when the end actuator moves to the right top of destination drive, the end actuator moves downward, stepper motor rotates in the opposite direction, the wedge moves upward, and mechanical fingers release.

In addition, because it is easy injury seedlings due to the rigid claw, many scholars begin the research of flexible end actuator. Minjuan Hu and others the deformation slide pin of tray seedlings, which is used to take seedlings [27]. Deformation slide pin to take seedlings is shown as in Figure 3.6. It is mainly composed of needle seat, needle to take seedling, needle tubing and so on. Not only does it require needle to take seedlings bending deformation under the guide of the needle, but it also needs enough stiffness to insert the seedling pot with wear-resisting properties



1 Grasp the Stepper Motor; 2 Screw; 3 Wedge Block; 4 Tension Spring; 5 Mechanical Fingers

Figure 3.5. End Actuator Deformation of Seedling Transplanting



1 Needle Seat; 2 Sliding Needle to take Seedlings; 3 Needle Tubing Seat; 4 Locking Nut; 5 Needle Tube

Figure 3.6. Deformation Sliding Pin Type of the Seedling Pick-Up Device

Beijing agricultural information technology research center has developed a flexible gripper that can adjust the clamping force of the transplantation, which use the elastic mode of clamping actively, so not only does it can ensure sufficient clamping, but it can prevent the rigid clamping, which damage the roots of the seedlings, as shown in Figure

3.7 [28]. In addition, change the fixed position of guide plate relative to the push rod in order to adapt to the different standards of transplanting.

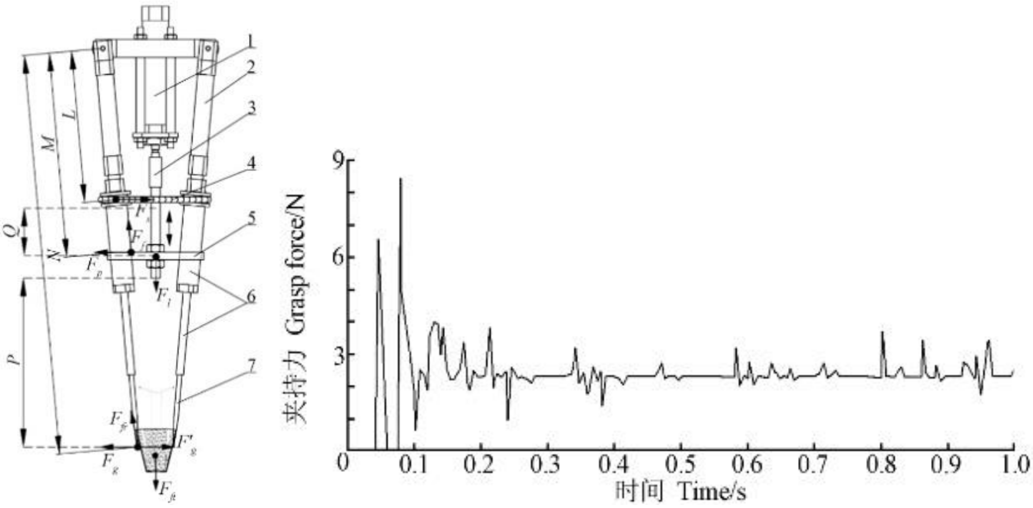


Figure 3.7. Flexible Adjustable Transplanting Claw Clamping Force and the Clamping Force Curve

The design of the end effector of automatic transplanting system working is influenced by environment and objects, and it has unique characteristics, mainly shows in: 1) The influence of properties of mortar. When the end effector of automatic transplanting system is working, the holding part for fingers is composed of a pot body matrix. So in order to remove and maintain seedlings successfully, finger-clamping force cannot exceed failure strength the bowl. There are many factors affecting the pot body, which contains matrix composition, water content of substrate and root structure. 2) Limitation of plug slot size. In the process of transplanting seedlings, put finger of the end effector into the substance of the tray hole, which requires the size after the end effector of the fingers open is less than not only than the seedling pot body size and the size of the hole, thus it is limited to the structure and size of fingers. Therefore, based on the characteristics of the end actuator, using flexible claw, which is not easy to hurt seedlings to achieve the automation and intelligentize is the focus of the study of the end effector.

3.3. Control System and Route Optimization

Control system is the key technology to achieve automation, intelligentize in automatic transplanting system. In the transplanting process of automatic seedlings transplanting machine, as the power and driving device, the control system integrates and complete actions of various parts of the actuator, and its performance directly affects the overall efficiency of automatic transplanting system and value. Control technology developed with the processing control technology, communication technology, computer technology and automatic monitoring technology. An integrated control technology contains two parts, which are hardware technology and software technology [29].

Gang Sun carried out the research on automatic transplanter for lettuce, and its control system is 16 bit C/OS-II embedded operating system micro controller, whose input channel includes the acquisition and processing of various signals and output control drive relays, electromagnetic valve and stepper motor [30]. SuboTian *et al*. designs a plug seedling transplanting manipulator control system based on PLC. The system is composed of controlled by programmable logic controller (PLC), a travel switch and so on. The hardware structure of the control system contains the selection of the cylinder, the travel switch and the electromagnetic valve, and the distribution of input and output interfaces and the design of PLC control system wiring diagram [31]. Kai Liu and others further study the application of PLC in seedlings transplanting robot control system. Based on the distribution of seedlings, which is standard of graft in the tray, state information of transplanting manipulator and the tray location information fusion, PLC control system of transplanting robot was designed [31]. Through the reasonable combination of 2 PLC and the design of control system, the control system of multi motor architecture was achieved, which make a software foundation for smooth of transplanting robot, and orderly operation. Minjuan Hu developed the automatic transplanting the software platform by using LabVIEW, and the platform has two kinds of motion control mode, which are inching and automatic, test parameters, test results analysis and recording, storage and other functions, which has a good human-computer interaction interface. The results show that measurement and control of the system has high precision and sensitivity of [33].

In addition, some scholars use PC machine to achieve the control of intelligent transplanting because the method of controlling function is more perfect. As for the control requirements of transplanting machine hand location about multi degree of freedom, Qingchun Feng uses the multi-level control models of PC [28]. Upper controller of PC host connected to 3-axis controller of multiple SMC6480 type through the Ethernet routing to achieve positioning control of the motor to the transplanting hands. 3 axis controller I/O contactors can be used to receive origin detection of various positioning mechanism, spacing and signal to start or stop, and it can output control signal of clamping gripper cylinder solenoid valve, thus changing the state of claw, and as the lower controller it can provide a reliable hardware support for the expansion of different number of transplanting grippers. Seedling image can be transmitted Color camera to the PC through 1394 data acquisition card, and according to the detection results of seedlings, locate high quality seedling hole, so we can control the corresponding position and clamping state.

Randomness of hole positions in the target tray and different choices of transplanting seedlings in the transplanting trays, which results that the path distance of transplanting seedling will change with different orders of replants. In order to make the control system more efficient, there is a need to optimize the path of the end effector to transplant at least. Junhua Tong put forward a set of suitable model to solve the problem of path optimization based on the genetic algorithm, and he took an analysis of typical example of the effectiveness of the algorithm [34], and the simulation results show that compared with the fixed order path length of conventional optimization, path length obtained by the proposed algorithm is better. The transplanting optimization rate of 50 strains of seedling is 8.5% above, the path is shortening more than 3.7 m, and the average operation time is 0.65s. Through controlling system design and optimization of transplanting path, the seedling transplanting efficiency can be significantly improved, which is the key technology to achieve factory-like automatic filling and transplanting.

4. Existing Problem and Development

Visual inspection of tray seedlings and automatic transplanting is automation equipment, which integrated seedling identification, function of clamping and transplanting, and it relates to the mechanical structure, machine vision, robot dynamics, sensor technology, control technology, and many fields of technology such as processing of computing information. In recent years, research on visual inspection system of tray seedlings and automatic transplanting system and automatic have got certain development in China, but this still remain in the stage of technical verification and there is still a large gap with commercial applications, which mainly has the following problems:

1) Lack of research on key technology. Visual inspection of Seedling transplanting, end effector, control system and path optimization is the key technology to achieve the intelligent and automatic transplanting, but the domestic research is still unable to meet the actual needs, for example, overlapping of seedling leaf, crossing, deformation and

other factors will lead to big errors of vision detection. flexible gripper of end effector is still on the stage of exploration, and error research on control system is not perfect.

2) Restrict of transplanting agronomic conditions. Because there is a requirement that the automatic transplanting system should adapt to the agricultural environment that is not standardized, which can easily lead to a sharp increase in manufacturing cost. Therefore, the seedling planting environment need to be changed to improve the operation performance of transplanting seedling cultivation system, such as the components of the substance, which can make the gripper clamp and release roots more reliably; improve the degree of standardization of seedling planting, and reduce the initial error in the process of transplanting.

3) Bad versatility of transplanting equipment. The use of pot seedling transplanting machine abroad began from factory-like pot transplanting in different size, and with the development of relative technology. Its application has been developed to seedling transplanting and harvesting of plant factory, flower seedlings trays and seedling transplanting, transplanting of tissue culture seedling and seedling sorting, which enhances the efficiency of relevant industry, to further promote the development of pot seedling transplanting technology. But in our country, transplanting equipment is limited to a certain function and universality of equipment is poor, which restricts the development of technology and market.

In view of the problems above, except brining in foreign automatic transplanting system, our country needs to study further to improve the key technology, put forward more suitable agronomic requirements of automatic transplanting system for China, enhance the universal automatic transplanting equipment, and achieve market popularization of automatic transplanting system in china as soon as possible.

Acknowledgments

This research was supported by Scientific Research Project of Higher Education of Inner Mongolia Autonomous Region, China (NJZY13052) (NJZY14034) and by Research Project of Inner Mongolia Natural Science Foundation, China (2015MS0631).

References

[1] Q. Feng and X. Wang, "The state of key technology research of intelligent tray seedlings", Research of agricultural mechanization, vol. 35, no. 11, **(2013)**, pp. 250-252.

[2] D. Chen, "Developing summarize of vegetables tray seedlings at home and abroad", Transactions of the Chinese Society of Agricultural Engineering; Transaction of the CSAE, 15(supplementary issue), **(1999)**, pp. 107-111.

[3] T. K. Bera, K. Bhattacharya and A. K. Samantaray, "Evaluation of antilock braking system with an integrated model of full vehicle system dynamics", Simulation Modelling Practice and Theory, vol. 19, no. 10, **(2011)**, pp. 2131-2150.

[4] G. Sun, X. Wang and G. He, "Design of end effector of tray seedlings transplanter and analysis of virtual prototype", agricultural mechanics magazine, no. 10, **(2010)**, pp. 48-53.

[5] L. Zhang, L. Qiu and S. Tian, "Design of tray seedlings transplanting claw with clamping needle", Magazines of Shenyang University of Agricultural, vol. 41, no. 2, **(2010)**, pp. 235-237.

[6] K. Liu and S. Gu, "The application of PLC in transplanting robot control system", Research of agricultural mechanization, vol. 31, no. 12, **(2009)**, pp. 179-180.

[7] P. Zhao, "Visual theory and application of machine", Beijing: Electronic Industry Press, **(2011)**.

[8] Y. W. Tai, P. P. Ling and K. C. Ting, "Machine vision assisted robotic seedling transplanting", Transactions of the ASAE (USA), **(1994)**.

[9] J. V. V. Albertus, "Multiple transplanting apparatus: US, 20040020110A1", **(2004)**, pp. 1-5.

[10] B. Wu, "Research on technology of content of water and soil, where greenhouse cucumber seedlings are based on computer image processing and inspecting", Huazhong Agricultural University, **(2007)**.

[11] K. Tsuga, S. Omori, T. Shigeyoshi and I. O. S. Kenzo, "Research (Yanmar agricultural machinery agricultural machinery Mitsubishi ㈱· ㈱)", cell tray seedling device for agriculture technology progress of 308 and 309 Money and motohiro Kojima Takayuki of full-automatic robot system in vegetable factory farm machinery development magazine of Jiuzhou 45,22 to 25, **(1996)**.

[12] Y. Y. Yamamoto and K. Y. N. Koichi, "Seedling selection device and at the open publication of unexamined and A 2003 52251 of P 52251 A 2003)", 2.25 Ltd, **(2003)**.

[13] X. Chen, Y. Zhou and X. Lu, “The application of technology of image processing in vegetables cultivation”, Agricultural and engineering, vol. 10, no. 4, **(1994)**, pp. 131-136.
[14] R. Zang, J. Wang and D. Zhang, “The application of mechanized visual technology on automatic transplanter”, Changjing vegetables, (02X), **(2009)**, pp. 15-17.
[15] F. Hu, W. Ying and C. Chen, “Recognition of tray seedlings based on mechanized vision and research of location”, Magazines of Northwest Agriculture & Forestry University: edition of natural science, vol. 41, no. 5, **(2013)**, pp. 183-188.
[16] Y. Mizuochi and M. Dohi, “Machine vision for transplanter of vegetables”, ASAE Annual Meeting, **(2003)**.
[17] Y. Ren, “Research on transplanting robot of facility agriculture based on machine vision”, Zhejiang University, **(2007)**.
[18] G. Sun, “Research on tray seedlings transplanting based on technology of machine vision”, Nanjing Agricultural University, **(2009)**.
[19] J. H. Tong, J. B. Li and H. Y. Jiang, “Machine vision techniques for the evaluation of seedling quality based on leaf area”, Biosystems Engineering, vol. 115, no. 3, **(2013)**, pp. 369-379.
[20] Y. Yang, Q. Cao and G. Sheng, “Location of tray and inspective system based on machine vision”, Agricultural Machinery Magazine, vol. 44, no. 6, **(2013)**, pp. 232-235.
[21] Y. Yang, K. C. Ting and G. A. Giacomelli, “Factors affecting performance of sliding-needles gripper during robotic transplanting of seedlings”, Applied engineering in agriculture (USA), **(1991)**.
[22] L. J. Kutz and J. B. Craven Jr., “Evaluation of photoelectric sensors for robotic transplanting”, Applied engineering in agriculture (USA), **(1994)**.
[23] K. H. Ryu, G. Kim, and J. S. Han, “Development of a robotic transplanter for beddingplants”, J. Agric. Eng. Res., vol. 78, no. 2, **(2001)**, pp. 141-146.
[24] W. C. Choi, D. C. Kim and I. H. Ryu, “Development of a seedling pick-up device for vegetable transplanters”, Transactions of the ASAE, vol. 45, no. 1, **(2002)**, pp. 13-19.
[25] G. Sun, X. Wang and G. He, “Design of Seedling Transplanting machine of end effector and Analysis on Virtual Prototype”, Journal of agricultural machinery, no. 10, **(2010)**, pp. 48-53.
[26] M. Hu and W. Yin, “Study on the pick-up device sliding pin deformation seedling”, Zhejiang Journal of Agricultural Sciences, vol. 23, no. 1, **(2011)**, pp. 154-158.
[27] Q. Feng, X. Wang and K. Jiang, “Design and test of key parts of flower seedling automatic transplanting machine”, Journal of Agricultural Engineering, vol. 29, no. 6, **(2013)**, pp. 21-27.
[28] Q. Wang, “Research of Automatic seedling pick-up mechanism control system”, Shihezi University, **(2013)**.
[29] G. Sun, T. Zhang and W. Zheng, “Study on automatic transplanter for lettuce”, Agricultural Engineering Science and technology innovation and construction of modern agriculture-Proceedings of the first symposium of China Institute of Agricultural Engineering, **(2005)**.
[30] S. Tian, L. Qiu and S. Zhang, “Based on design of PLC plug seedling transplanting manipulator control system”, Journal of Shenyang Agricultural University, vol. 38, no. 1, **(2007)**, pp. 122-124.
[31] K. Liu and S. Gu, “Application of PLC in seedling transplanting robot control system”, Study on Agricultural Mechanization, vol. 31, no. 12, **(2009)**, pp. 179-180.
[32] M. Hu, W. Ying and F. Hu, “Development of seedling automatic picking seedling test system”, Journal of Nanjing Agricultural University, vol. 34, no. 3, **(2011)**, pp. 122-126.
[33] J. Tong, H. Jiang and M. Zhou, “Based on automatic path optimization of the genetic algorithm of seedling transplanting”, Journal of agricultural machinery, vol. 44, no. 4, **(2013)**, pp. 45-49.

Authors

Dongmei Pei, received the BS degrees in computer science from University of Science & Technology Beijing, China, in 1999 and received the MS degrees in computer science from Inner Mongolia Normal university, China, in 2008. Her research interests include Code plagiarism detection, management Information system and compression and storage algorithm.

Meng Fanjun, received the BS and MS degrees in computer science from Inner Mongolia Normal University, China, in 1999 and 2007. Currently, his research interests include scheduling techniques and parallel algorithms for clusters, and also multi-core processors and software techniques for I/O-intensives applications.

Hailong Wang, received the BS in computer science from North Jiaotong Univesity, China, in 1998 and received the MS in computer science from Lanzhou Jiaotong University, China, in 2007. Currently, he is an assistant professor in Computer & Information Engineering College at Inner Mongolia Normal University, China. His Research interests include embedded system and multi-core processor and also fault tolerance and real-time database.