Robot for Ball Fetch-and-Carry with Computer Vision in Deep Learning

Limin Su*, Chao-Jen Huang*, Mei Liu*, Bing-Yuh Lu*, Jidong Che*,
Ximiao Wang*, Jiqi Feng*, Changyong Li*, Youhong Feng*, Yueliu Mo**

*Faculty of Automation, Guangdong University of Petrochemical Technology, Guangdong, China
**Faculty of Business administration, Guangzhou College of Technology and Business, Guangdong, China.

franklinlu888@outlook.com

Abstract— **A robot which functioned as fetch-and carry ball sever was implemented. The structure of this robot are (1) Raspberry Pi for processor; (2) a camera for computer vision; (3) a 4-wheel model car for carry; and (4) robot arms for the mechanism of fetching ball. The computer vision in deep learning technology makes the robot pick the balls quickly. For the safety, the navigation and anti-collision modules were embedded in the robot. The results presented that the number of successful fetch-and-carry is in the range of 69 to 88 times in the competition of working in 100 minutes to pick the table tennis balls. Therefore, the technology can be developed to be a fetch-and-carry server for other balls in the near future.**

***Keywords*—AI, ball, deep learning, fetch-and-carry, Raspberry Pi, robot**

I. Introduction

For educational purpose, many robot competitions have been token place for students' training of the techniques of robotics [1-5]. One of the competitions is to design a robot for fetch-and-carry balls [6-9]. The educators and students need to focus on the design and implementation of programming microprocessors, sensors, robotics, navigation technology, computer vision, 3D printing and even cover design. Therefore, many institutes and companies support budgets and technologies to hold on the robotic competitions, such as SICK Robot Day, TDK Cup and so on.

Furthermore, according to the "Thirteenth Five-Year Plan for the Development of the Sports Industry in China" issued by National Sports General Administration, China's total output value of the sports industry is more than 2.600 billion yuan in 2019, and will be expected to reach 3.5 trillion yuan by 2023. Behind China's developed sports industry, there is bound to be an urgent demand for sports equipment (Fig. 1). Notably, with the development of science and technology, this demand of the sports will shift to a higher technological content in the world. The smarter devices will be increased and widely used in many sports.

The object of this study is to design and implement a robot for fetch-and-carry balls. The structure of this robot are (1) Raspberry Pi for processor; (2) a camera for computer vision; (3) a 4-wheel model car for carry; and (4) robot arms for the mechanism of fetching ball. The computer vision in deep learning technology makes the robot pick the balls quickly.

This study included five sections. Introduction section presented the motivation and literature study of this article. Method section introduced components and their connections. Results section presented function of robot and all of the system. Discussion section showed advantages and disadvantages of the robot. Finally, a short conclusion presents in the last section.

Fig. 1 Modern table tennis training room in China

II. Methods

The functional block diagram of the robot for fetch-and-carry balls is presented in Fig. 2. The devices are introduced as follows,

A. Micro controller

Raspberry Pi systems-on-chip was employed to be the central processor of the robot. The Raspberry Pi 4, with a quad-core ARM Cortex-A72 processor, full gigabit Ethernet, and available with 2, 4 or 8GB of RAM. The video controller can generate standard modern TV resolutions, such as HD and Full HD [10-15].

B. Camera for computer vision

The computer vision is based on the deep learning of the artificial neuron network [16-19]. The number of the picture for training is 2000. Some of the training samples are presented in Fig. 3. The server is TensorFlow provided by Alibaba Cloud. The computer vision in the TesorFlow has been implemented in deep learning to analysis more than 10,000 pictures. The camera of the robot is responsible for taking pictures and obtaining images of the training target and then connecting with the server in the Internet to upload the pictures. Some of the training results are embedded in the Raspberry Pi to recognize the balls. However, if some cases can not recognize the ball, it will sent to the TensorFlow provided by Alibaba Cloud for recognition and training.

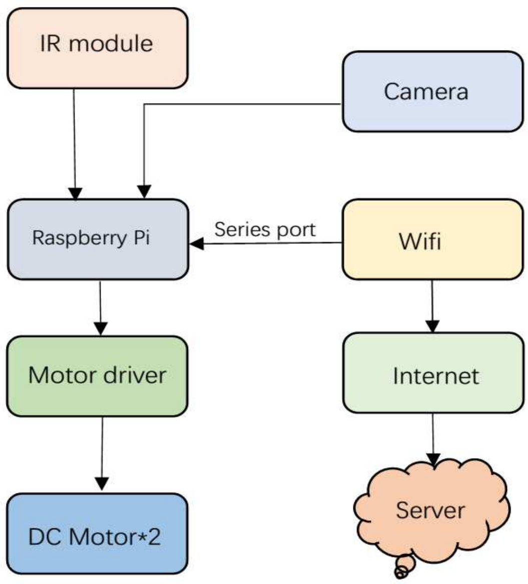

Fig. 2 Functional block diagram of the robot

C. 4-wheel model car for carry

2 tank-type tracked wheels with the motor drive module were employed for the movable carrier of the electric heating radiator. The carrier was controlled by the IO port of STM32 G0. The key chip of motor drive module was L298N which was functioned by dual H-bridge. The range of power supply is 5 to 35V (dc). The maximum output current is 2A (the instantaneous peak current is 3A), and the maximum output power is 25W. The speeds of the wheels were tuned by pulse width modulation (PWM) technology where the duty cycles of the driving pulses were modulated by timers.

D. Robot arms for the mechanism of fetching ball

The robot arms for mechanism for fetching ball were designed by 3D printing [20-21]. The arms with several jokes and the notches can fetch the ball very stably. The camera is located on the centre of the beginning of arms to catch a ball using the computer vision. This design is aimed at the easier control of the robot arms.

E. Tests

For testing the performance of the robot, an experiment was design. The test is based on picking up table tennis balls. The test method is to place 100 table tennis balls in a specific area and record the number of picking up balls within the specified 10 minutes. The qualification rule is that the average picking speed is less than or equal to 8 seconds per ball, i.e. 75 fetches in 10 minutes.

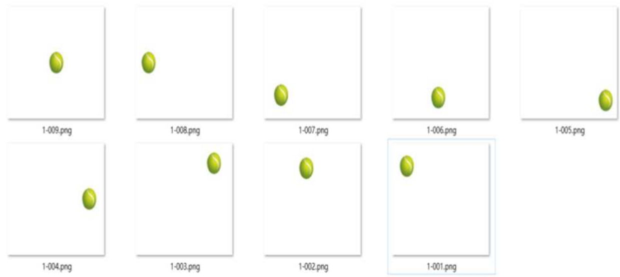

Fig. 3 Samples of the training pictures

III. RESULTS

A. Robot

The robot for fetch-and-carry ball is illustrated in Fig. 4. In this picture, (a) is the camera, (b) is the robot arms for the mechanism of fetching ball, (c) the control board, and (d) the wheels. The speed of the robot is less than 25 cm/sec.

B. Settings

The setting program of the robot was shown in Fig. 5. It counted the times of the successful fetches in a duration as well as set target times of the successful fetches.

C. Tests

The measurement is to count the successful picks of the ball during 10 minutes. The results were listed in Fig. 6. The maximum number of the picks is 88, and the minimum is 69. The qualification rule is that the average picking speed is less than or equal to 8 seconds per ball, i.e. 75 fetches in 10 minutes. Therefore, 18 tests were pass, but 2 test was fail. The average of successful picks of the ball during 10 minutes is 80.5 fetches. The standard deviation is 5.1 fetches.

IV. DISCUSSION

The sports industry will develop soon, because the global population is increasing. Moreover, the population of elders is going to increase soon in many countries. The elders are much richer than ones before. Therefore, some of them will do exercises more. Modern parents wish their children to be wise and healthy. Therefore, the training of doing some exercises is necessary to their children. Consequently, the smart device for sports is a potential issue.

Fig. 4 The robot for fetch-and-carry ball. (a) camera; (b) Robot arms for the mechanism of fetching ball; (c) controller board; and (d) wheels.

Fig. 5 The setting program of the robot

However, this is a preliminary study for the ball fetch-and-carry robot. Some of the hardware and software should be improved,

(a) The moving speed of the robot can be accelerated by employing the higher power motors.
(b) The location of the camera should be adjusted to a higher position for a better view for fetching balls.
(c) The geometric parameters of the robot arms should be newly designed to improve the successful rate of touched balls. In another word, to enlarge the size of the arms may be a better strategy.

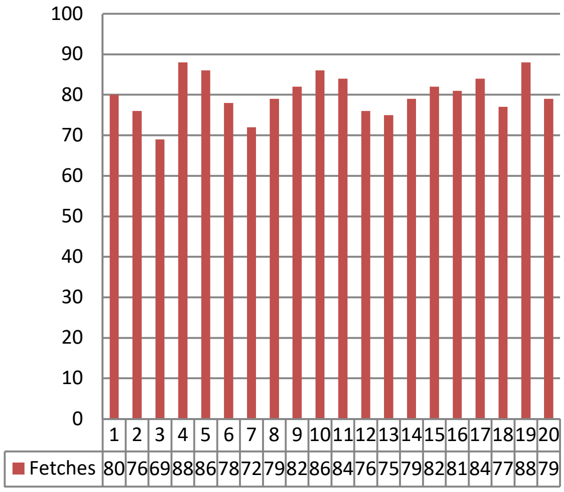

Fig. 6 The results of tests

V. Conclusion

A robot for ball fetch-and-carry was implemented. It can be improved for a better performance to fetch the balls efficiently. Because the sports market will develop soon, the commercial smart device for sports is a potential issue for the relative researches.

Acknowledgments

The authors thank for the support from Guangdong University of Petrochemical Technology, Guangdong, China (Project number: 702-519244).

References

[1] Mizuchi, Y., & Inamura, T. (2020). Optimization of criterion for objective evaluation of HRI performance that approximates subjective evaluation: a case study in robot competition. Advanced Robotics, 34(3-4), 142-156.

[2] Han, Y. H., Jeon, H. J., & Cho, B. K. (2020). Development of a Humanoid Robot for the 2018 Ski Robot Challenge. International Journal of Precision Engineering and Manufacturing, 1-12.

[3] Chiang, F. K., Liu, Y. Q., Feng, X., Zhuang, Y., & Sun, Y. (2020). Effects of the world robot Olympiad on the students who participate: a qualitative study. Interactive Learning Environments, 1-12.

[4] Norman, D. A., Mimlitch III, R. H., & Adams, P. S. (2004). U.S. Patent No. 6,674,259. Washington, DC: U.S. Patent and Trademark Office.

[5] Yanco, H. A., Drury, J. L., & Scholtz, J. (2004). Beyond usability evaluation: Analysis of human-robot interaction at a major robotics competition. Human–Computer Interaction, 19(1-2), 117-149.

[6] Antão, L., Sousa, A., Reis, L. P., & Gonçalves, G. (2020, July). Learning to Play Precision Ball Sports from scratch: a Deep Reinforcement Learning Approach. In 2020 International Joint Conference on Neural Networks (IJCNN) (pp. 1-8). IEEE.

[7] Huang, P. C., & Mok, A. K. (2018, August). A Case Study of Cyber-Physical System Design: Autonomous Pick-and-Place Robot. In 2018 IEEE 24th International Conference on Embedded and Real-Time Computing Systems and Applications (RTCSA) (pp. 22-31). IEEE.

[8] Cigolini, M., Costalunga, A., Parisi, F., Patander, R., Salsi, I., Signifredi, A., ... & Caselli, S. (2014). Lessons learned in a ball fetch-and-carry robotic competition. Journal of Automation Mobile Robotics and Intelligent Systems, 8.

[9] Tan, N., Mohan, R. E., Foong, S., Yamakita, M., Iwase, M., Hatakeyama, S., ... & Zhu, Q. (2016). IDC robocon: a transnational teaming competition for project-based design education in undergraduate robotics. Robotics, 5(3), 12.

[10] Prabha, S. S., Antony, A. J. P., Meena, M. J., & Pandian, S. R. (2014, April). Smart cloud robot using raspberry Pi. In 2014 International Conference on Recent Trends in Information Technology (pp. 1-5). IEEE.

[11] Bokade, A. U., & Ratnaparkhe, V. R. (2016, April). Video surveillance robot control using smartphone and Raspberry pi. In 2016 International Conference on Communication and Signal Processing (ICCSP) (pp. 2094-2097). IEEE.

[12] Li, X. Q., Ding, X., Zhang, Y., Sun, Z. P., & Zhao, H. W. (2016, June). IoT family robot based on Raspberry Pi. In 2016 International Conference on Information System and Artificial Intelligence (ISAI) (pp. 622-625). IEEE.

[13] Amrutha, J. N., & Rekha, K. R. (2020). Night Vision Security Patrolling Robot Using Raspberry Pi. International Journal of Research in Engineering, Science and Management, 3(8), 432-436.

[14] Lemos, E., Ghoshal, A., & Aspat, A. (2020). Hardware Architecture and Implementation of an AI Pet Robot. International Journal of Applied Sciences and Smart Technologies, 2(2), 21-46.

[15] Chen, A., Yang, B., Cui, Y., Chen, Y., Zhang, S., & Zhao, X. (2020). Designing a Supermarket Service Robot Based on Deep Convolutional Neural Networks. Symmetry, 12(3), 360.

[16] Zhang, Z., Kayacan, E., Thompson, B., & Chowdhary, G. (2020). High precision control and deep learning-based corn stand counting algorithms for agricultural robot. Autonomous Robots, 44(7), 1289-1302.

[17] Nica, E., Kliestik, T., Sabie, O. M., & Ioanei, M. L. (2020). Socio-Affective Technologies for Psychological Health: Emotional Artificial Intelligence in Empathetic Robots. American Journal of Medical Research, 7(2), 9-14.

[18] Bhandari, B., & Park, G. (2020). Development of a real-time security management system for restricted access areas using computer vision and deep learning. Journal of Transportation Safety & Security, 1-16.

[19] Ahmad, I., & Pothuganti, K. (2020, August). Design & implementation of real time autonomous car by using image processing & IoT. In 2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT) (pp. 107-113). IEEE.

[20] Sun, Z. N., Chen, X., Li, H., & Zou, S. (2012). Design of the indoor golf robot for automatic picking up and putting the ball based on Fischertechnik model. In Applied Mechanics and Materials (Vol. 220, pp. 1116-1119). Trans Tech Publications Ltd.

[21] Branson, D. T., Kang, R., Guglielmono, E., & Caldwell, D. G. (2012, May). Control architecture for robots with continuum arms inspired by octopus vulgaris neurophysiology. In 2012 IEEE International Conference on Robotics and Automation (pp. 5283-5288). IEEE.

Limin Su is currently a student with Faculty of Automation, Guangdong University of Petrochemical Technology, Guangdong, China.

Chao-Jen Huang is currently an associate professor with Faculty of Automation, Guangdong University of Petrochemical Technology, Guangdong, China.

May Liu is currently the Dean of Academic Affairs, and a professor with Faculty of Automation, Guangdong University of Petrochemical Technology, Guangdong, China.

***Bing-Yuh Lu** is currently a professor with Faculty of Automation, Guangdong University of Petrochemical Technology, Guangdong, China.

Jidong Chen is currently a student with Faculty of Automation, Guangdong University of Petrochemical Technology, Guangdong, China.

Jiqi Feng is currently a student with Faculty of Automation, Guangdong University of Petrochemical Technology, Guangdong, China.

Ximiao Wang is currently a student with Faculty of Automation,Guangdong University of Petrochemical Technology, Guangdong, China.

Changyong Li is currently a student with Faculty of Automation, Guangdong University of Petrochemical Technology, Guangdong, China.

Youhong Feng is currently a student with Faculty of Automation,Guangdong University of Petrochemical Technology, Guangdong, China.

Yueliu Mo is currently a student with Faculty of Business administration, Guangzhou College of Technology and Business, Guangdong, China.