出國報告（出國類別：其他-國際會議）

2017 ICAROB 國際研討會

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派赴國家：日本
出國期間：2017/01/18~2017/01/21
報告日期：2017/02/15

摘要

於 2017 年 1 月 19 至 2017 年 1 月 22 日參與 ICAROB 國際研討會，本次研討會地點為日本宮崎，此研討會有來自全球多個國家的學者與師生與會，本次共有 2 篇文章在大會議程中發表，題目為：

1. Based on Short Motion Paths and Artificial Intelligence Method for Chinese Chess Game.
2. Design and Implementation of the SCARA Robot Arm.

抵達會場後，走到達櫃台處進行報到，並領取會議資料，透過參與研討會方式可使相關的研究獲得交流，並且使國際間相關領域之學者，能夠了解台灣在這方面研究的成果與成績。在本次的會議中可以看出論文品質及研發方向有很大的提升，在本次會議中能認識其他國家的人士，彼此能交換心得，對於開拓視野、提升研究品質有莫大的幫助。

目錄

一、 目的

2017 年 ICAROB 國際研討會在日本宮崎舉行，會議時間自 1 月 19 日至 1 月 22 日。此研討會有來自全球多個國家的學者與師生與會，有多達 200 餘篇論文在會議中發表，本次共有 2 篇文章在大會議程中發表，題目為：

1. Based on Short Motion Paths and Artificial Intelligence Method for Chinese Chess Game.
2. Design and Implementation of the SCARA Robot Arm.

透過參與研討會方式可使相關的研究獲得交流，並且使國際間相關領域之學者，能夠了解台灣在這方面研究的成果與成績。

二、 過程

抵達會場後，可在門口清楚看到演討會立牌，在往內走到達櫃台處進行報到，並領取會議資料，與會期間聽取各界學者們分享各自技術成效，本人在本次會議中發表 2 篇論文。

在第一篇論文中，主要為應用群組機器人系統並配合 AI、A*及運動控制等方法，將此系統套用於中國象棋進行應用，可使得人與電腦進行對戰，電腦則經由 AI 計算其下一步棋下法，經由 A* search 演算法計算移動路線，並經由 Wireless RF module 將各命令傳送至機器人，使機器人依照路線行走，當發生吃棋情況時，可計算 2 隻機器人各自移動路線，並將其碰撞問題解決，使得 2 隻機器人可進行同步移動。

第二篇論文，主要為機械手臂運動控制，採用 Delta 開發之整合型控制器，控制 4 軸伺服馬達移動，達到動作目標，此實驗包含精準定位(於對應位置上蓋章)、影像辨識(獲取物件位置資訊)並將其搬移至定點位置(物件搬移)。

參與研討會也接收到許多不同的技術領域，例如：影像辨識系統、車牌辨識系統、環境感測保全系統…等等，會議期間許多學者一同討論以及分享論文經驗，可增進自我見識，在研討會舉辦期間，參與會場所舉辦之 welcome 晚宴，可與許多不同國家學者一同聊天，分享各國趣事及文化，是個不錯的跨國交流。

三、 心得

AROB 為全球有關自動化、智慧型計算、控制系統與應用、能源與環境、機器人、訊號處理與網路通訊等之國際重要研討會之一，本次會議共有多達 200 篇論文發表，其中台灣也有多位國內大專院校參與，並有多篇文章發表。

透過研討會方式可使相關的研究獲得交流，並且使國際間相關領域之學者，能夠了解台灣在這方面研究的成果與成績，可提升台灣之學術地位。在本次的會議中可以看出論文品質及研發方向有很大的提升，本次會議中能認識其他國家的人士，彼此能交換心得，對於開拓視野、提升研究品質有莫大的幫助。茲將出席本次會議心得及建議分述如下：

1.會中透過討論與各國專家學者交流，獲益良多。

2.聽取不同領域之技術，可增廣自我的知識及引發新的思考與研究方法。

3.從各國學者發表之論文來看，可發現台灣學者在各項研究方面均有不錯的表現，但各國的研究及其技術皆有相當長足的進步，其相關整合與應用方面皆有不錯的表現，因此，藉由此類的會議可獲取各國間研究的專業領域技術，相互切磋成長。

四、 建議事項

1.政府應對相關領域之研究多加補助。

2.政府應對參加此類研討會之師生多加鼓勵，儘量補助參與名額及金額，以鼓勵學者積極參與國際學術會議。

五、 附錄

(一) 照片

圖一、抵達研討會會場

圖二、會議會場

圖三、與會人員(一)	圖四、與會人員(二)
	
圖五、報告過程(一)	圖六、報告過程(二)

(二)議程

The 2017 International Conference on Artificial Life and Robotics (ICAROB2017), Seagaia Convention Center, Miyazaki, Japan, January 19-22, 2017

1/19(Thu.) 17:30-19:30	Welcome Party (Conference Site: Gibraltar)
1/19(Thu.) - 1/22(Sun.)	ICAROB Secretariat
1/22(Sun.) 16:45-17:15	Farewell Party (Conference Site: Gibraltar)

TIME TABLE (1/20)

1/20(Fri.)	Fountain Room (A1) 2nd F	Orchard Room (A2) 2nd F, N	Orchard Room (A3) 2nd F, S
8:40-	Registration		
9:00-10:15	OS14 Advanced Control (5)	GS6 Human-Welfare Robotic System & Medical Application (5)	OS15 Recognition and Control (8) & OS16 Image Recognition and Chaotic Systems (8)
10:15-10:30	Coffee break		
10:30-11:00	Opening Ceremony (Fountain Room (A1) 2nd F)		
11:10-12:10	Chair: Takao Ito Invited session IS-2, IS-4 (Fountain Room (A1) 2nd F) Henrik Hautop Lund		
12:10-13:10	Lunch		
13:10-13:50	Chair: Jangmyung Lee Invited session IS-1 (Fountain Room (A1) 2nd F) Luigi Pagliarini		
13:50-14:10	Invited session IS-3 (Fountain Room (A1) 2nd F) Ismael Baira Ojeda		
14:10-14:30	Coffee break		
14:30-16:00	OS3 Intelligence Control Systems and Applications (II) (6)	OS5 Human Interface and Content Security (5)	GS7 Micro-Machines & Robotics I (6)
16:00-16:20	Coffee break		
16:20-17:50	OS2 Intelligence Control Systems and Applications (I) (6)	OS9 Theory and Implementation of Neuromorphic Systems (5)	OS7 Advances in Marine Robotics and Applications (6)

TIME TEBLE (1/21)

1/21(Sat.)	Fountain Room (A1) 2nd F	Orchard Room (A2) 2nd F, N	Orchard Room (A3) 2nd F, S
8:40-	Registration		
9:00-11:00	OS6 Software Development Support Method (6)	GS2 Automated Guided Vehicles I (6)	OS4 Human-In-The-Loop (HITL) Systems (4) & OS11 Robot Control and Localization (4)
11:00-11:15	Coffee break		
11:15-12:00	GS5 Filtering & Control Systems (2)	GS8 Micro-Machines & Robotics II (3)	GS1 Artificial Neural Network and Bio-Signal Controlled Robotics (3)
12:00-13:00	Lunch		
13:00-14:00	Chair: Yingmin Jia Plenary Speech PS1(Fountain Room (A1) 2nd F) Kazuo Ishii		
14:00-14:20	Coffee break		
14:20-15:50	OS20 Image Processing and Computer Graphics (6)	OS13 Intelligent Control (6)	OS8 Multiagent systems and Reality Mining (4)
15:50-16:10	Coffee break		
16:10-17:25	GS9 Neuromorphic Robotic Systems (5)	OS22 Robotic Technology for Competition (4)	GS4 Biological Systems (4)
18:00-20:00	Banquet: Tenzui (4th F)		

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TIME TABLE (1/22)

1/22(Sun.)	Fountain Room (A1) 2nd F	Orchard Room (A2) 2nd F, N	Orchard Room (A3) 2nd F, S
8:50-	Registration		
9:10-10:25	OS10 Biological Signal Sensing Technology, Device and Its Applications (5)	OS19 Kansei Engineering and Applications (4)	OS1 Informational Narratology and Automated Content Generation (5)
10:25-10:40	Coffee break		
10:40-11:40	Chair: Makoto Sakamoto Plenary Speech PS2 (Fountain Room (A1) 2nd F) Tomoyuki Nishita		
11:40-13:00	Lunch		
13:00-13:50	Chair: Takao Ito Invited session IS-5 (Fountain Room (A1) 2nd F) Peter Sapaty		
13:50-14:10	Coffee break		
14:10-15:10	OS18 Advanced Management and Technology (4)	OS17 Natural Computing and Biology (4)	OS12 Machine Learning and Its Applications (4)
15:10-15:30	Coffee break		
15:30-16:45	GS10 Reinforcement & Evolutionary Computations (3)	GS3 Automated Guided Vehicles II (3)	OS21 Computer Science and Information Processing (5)
Farewell Party (16:45-17:15)			

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OS3-6 *Surface Defect Detection for Anodized Aluminum Tube Based on Automatic Optical Inspection*
Hsien-Huang P. Wu and Hsuan-Min Sun
(National Yunlin University of Science and Technology, Taiwan)

16:20-17:50

OS2 Intelligence Control Systems and Applications I (6)

Chair: Kuo-Hsien Hsia (Far East University, Taiwan)

Co-Chair: Kuo-Lan Su (National Yunlin University of Science & Technology, Taiwan)

OS2-1 *Develop Low Cost IoT Module with Multi-Agent Method*
Jr-Hung Guo, Kuo-Hsien Hsia, Kuo-Lan Su
(National Yunlin University of Science and Technology, Taiwan)

OS2-2 *Based on Short Motion Paths and Artificial Intelligence Method for Chinese Chess Game*
Chien-Ming Hung, Jr-Hung Guo, Kuo-Lan Su
(National Yunlin University of Science and Technology, Taiwan)

OS2-3 *Design and Implementation of the SCARA Robot Arm*
Jian-Fu Weng, Bo-Yi Li, Kuo-Lan Su
(National Yunlin University of Science and Technology, Taiwan)

OS2-4 *Transmission Power Control for Wireless Sensor Network*
Kuo-Hsien Hsia[1], Chung-Wen Hung[2], Hsuan T. Chang, Yuan-Hao Lai[2]
([1]Far East University, Taiwan, [2]National Yunlin University of Science and Technology, Taiwan)

OS2-5 *Mechanism of Autonomous Mowing Robot for Long Grass*
Kuo-Hsien Hsia[1], Yao-Shing Huang[2], Kuo-Lan Su[2] and Jr-Hung Guo[2]
([1]Far East University, Taiwan, [2]National Yunlin University of Science and Technology, Taiwan)

OS2-6 *Design of Optimal Position Controller for Three-Phase Brushless DC Motor Applying Adaptive Sliding Mode Control*
Tai-Huan Tsai, Mei-Yung Chen (National Taiwan Normal University, Taiwan)

Orchard Room (A2) 2nd F, N

9:00-10:15 GS6 Human-Welfare Robotic System & Medical Application (5)

Chair:

GS6-1 *Virtual surgery system with realistic visual effects and haptic interaction*
Vlada Kugurakova, Murad Khafizov, Ruslan Akhmetsharipov, Alexei Lushnikov, Diana Galimova, Vitaly Abramov (Kazan Federal University, Russia),
Omar Correa Madrigal (University of Informatic Sciences, Cuba)

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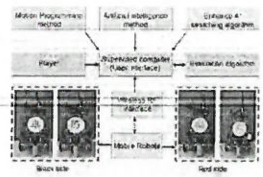
(三) 發表論文摘要

The 2017 International Conference on Artificial Life and Robotics (ICAROB2017), Seagaia Convention Center, Miyazaki, Japan, January 19-22, 2017

OS2-2 Based on Short Motion Paths and Artificial Intelligence Method for Chinese Chess Game

Chien-Ming Hung, Jr-Hung Guo, Kuo-Lan Su
(National Yunlin University of Science and Technology, Taiwan)

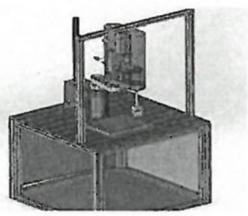
The article develops the decision rules to win each set of the Chinese chess game using evaluation algorithm and artificial intelligence method, and uses the mobile robot to be instead of the chess, and presents the movement scenarios using the shortest motion paths for mobile robots. User can play the Chinese chess game according to the game rules with the supervised computer. The supervised computer decides the optimal motion path to win the set using artificial intelligence method, and controls mobile robots according to the programmed motion paths of the chesses moving on the platform via wireless RF interface. We use enhanced A* searching algorithm to solve the shortest path problem of the assigned chess, and solve the collision problems of the motion paths for two mobile robots moving on the platform simultaneously. We implement a famous set to be called "wild horses run in farm" using the proposed method. First we use simulation method to display the motion paths of the assigned chesses for the player and the supervised computer. Then the supervised computer implements the simulation results on the chessboard platform using mobile robots. Mobile robots move on the chessboard platform according to the programmed motion paths and is guided to move on the centre line of the corridor, and avoid the obstacles (chesses), and detect the cross point of the platform using three reflective IR modules.



OS2-3 Design and Implementation of the SCARA Robot Arm

Jian-Fu Weng, Bo-Yi Li, Kuo-Lan Su (National Yunlin University of Science and Technology, Taiwan)

The article designs a four-joint robot arm using PLC-based control system. The control system is all in one device to be produced by the DELTA Company, and contain four axis controllers and drivers. The robot arm contains four AC servomotors, four driver devices and a vision system. The PLC-based controller also programs motion commands of the gripper to finish the assigned tasks using Ladder Diagram (LG), Function Block Diagram (FBD), Sequential Function Chart (SFC), Instruction List (LL) and Structure Test (ST). Each driver has been tuned the parameters of the PID controller for the robot arm. The human machine interface (HMI) is a touch panel to be used for the robot arm. Users can control the motion path of any joint on the user interface. In the experimental results, users can program English or Chinese words or plot assigned graphs on the human machine interface. The SCARA robot arm catches the pencil, and put down to touch the assigned position repeat on the platform, and identifies the precious of the robot arm, and catches various objects to put down the assigned positions.



Based on Short Motion Paths and Artificial Intelligence Method for Chinese Chess Game

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Abstract

The article develops the decision rules to win each set of the Chinese chess game using evaluation algorithm and artificial intelligence method, and uses the mobile robot to be instead of the chess, and presents the movement scenarios using the shortest motion paths for mobile robots. User can play the Chinese chess game according to the game rules with the supervised computer. The supervised computer decides the optimal motion path to win the set using artificial intelligence method, and controls mobile robots according to the programmed motion paths of the chesses moving on the platform via wireless RF interface. We use enhanced A* searching algorithm to solve the shortest path problem of the assigned chess, and solve the collision problems of the motion paths for two mobile robots moving on the platform simultaneously. We implement a famous set to be called "wild horses run in farm" using the proposed method. First we use simulation method to display the motion paths of the assigned chesses for the player and the supervised computer. Then the supervised computer implements the simulation results on the chessboard platform using mobile robots. Mobile robots move on the chessboard platform according to the programmed motion paths and is guided to move on the centre line of the corridor, and avoid the obstacles (chesses), and detect the cross point of the platform using three reflective IR modules.

Keywords: Evaluation algorithm, artificial intelligence method, wireless RF interface, enhance A* searching algorithm

1. Introduction

Chinese chess game is one of the most popular games, and is similar to Western chess to be a two-player game with a complexity level, and is classified red side and black side. In the recent, the Chinese chess game has gradually attracted many researchers' attention, and many evolutionary algorithms to be proposed. Darwen et al. proposed the co-evolutionary algorithm to solve problems where an object measure to guide the search process is extremely difficult to device [1].

In the paper, we use the multi-robot system to present the scenario of the Chinese chess game, and uses enhance A* searching algorithm to program the shortest path for mobile robots (chesses) moving to the target points. Player moves the chess to the assigned location or takes the chess of the supervised computer. Then there are two chesses (robots) moving in the platform simultaneously. The assigned two robots may collide on the programmed motion paths. The proposed algorithm can solve the collision condition of two mobile robots and improve the shortest motion path using enhance A* searching algorithm [2, 3].

In some condition, the mobile robot must programs the shortest path and avoids the other chess moving to the next position. A* heuristic function is introduced to improve local searching ability and to estimate the forgotten value [4]. Flavio et al. presented a multi-robot exploration algorithm that aims at reducing the exploration time and to minimize the overall traverse distance of the robots by coordinating the movement of the robots performing the exploration [5].

2. System Architecture

The system architecture of the Chinese chess game system is shown in Fig. 1. The system contains a supervised computer, some wireless RF modules, a grid based platform, thirty-two mobile robots and some wireless modules. The game is classified red side (User) and black side (The supervised computer), and belongs to two players. Each side includes sixteen chesses. Player moves chess using the mouse on the user interface, or takes chess of the other side. The chess game will be ending until the king of each side to be taken by another side.

We want to increase the entertainment function using mobile robots to present the movement scenarios of the chesses. The supervised computer is a player to compete with the user, and programs the shortest motion path using enhance A* searching algorithm and transmits the ID code and motion command to the assigned mobile robots. The assigned mobile robots receive the self-ID code and the target positions via wireless RF interface, and move to the assigned positions to avoid the collision paths according to the programmed motion paths.

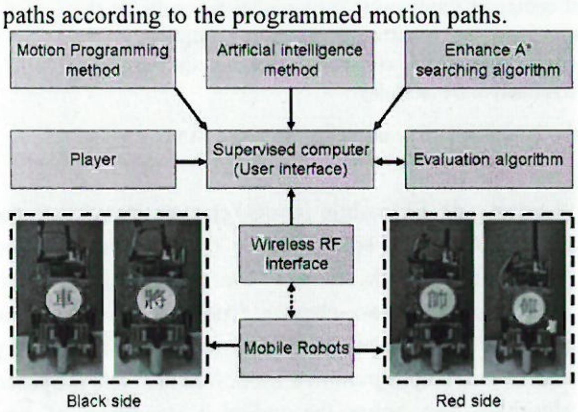

Fig. 1. System architecture

In the collision problem, player moves chess to take chess of the other side. The user interface programs two motion paths for the assigned chesses. Two mobile robots avoid collision points and paths according to the programmed motion paths moving on the platform. Players can set game time of each set and limit moving time of each step. Players don't obey the game rules to move chess using the mouse. The supervised computer can't permit and display the movement status on the user interface.

3. Motion Planning

The mobile robot has the shape of cylinder, and it's equipped with a microchip (STC12C5A60S2) as the controller, two DC servomotors and two driver devices, some sensor circuits (contain compass circuit), a voice module, three Li batteries, a wireless RF interface (2.4GHz) and three reflect IR sensor modules (One module contains two reflective IR sensors). Meanwhile, the mobile robot has four wheels to provide the capability of autonomous mobility. The structure of the mobile robot is shown in Fig. 1.

The mobile robot uses three reflective IR modules to detect the wall of each grid and obstacles. Two reflective IR sensors are fixed on the both sides of the mobile robot. The detection distance of the front side is shorter than the behind side shown in Fig. 2(a). In the both side's modules, two reflective IR sensors of the front side can detect distance to control the mobile robot moving in the centre line of the corridor shown in Fig. 2(b). Two reflective IR sensors can detect the maximum distance to be equal to the width of the corridor minuses the width of the mobile robot to be fixed on the behind side of the module shown in Fig. 2(c). The other reflective IR module is fixed on the front side, and detects the object or the mobile robot on the motion path.

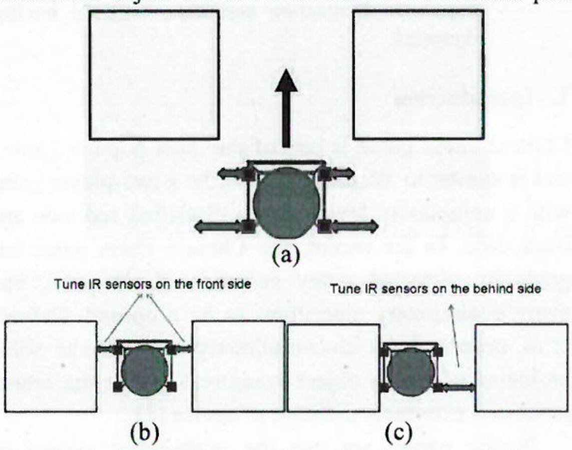

Fig. 2. The detection range for reflective IR modules

A^* searching algorithm solves the path planning problem of multiple nodes travel system. The formula of A^* searching algorithm is following

$$f(n) = g(n) + h(n) \tag{1}$$

The core part of an intelligent searching algorithm is the definition of a proper heuristic function $f(n)$. $g(n)$ is the exact cost at sample time n from start point to the next point. $h(n)$ is the minimum cost. In this study, n is reschedules as n' to generate an approximate minimum cost schedule. The equation (1) can be rewritten as follows:

$$f(n) = g(n) + h(n') \tag{2}$$

The A* searching algorithm can program local minimum motion path. We improve A* searching algorithm that is called enhance A* searching algorithm, and searches the shortest motion path for mobile robots [7]. In the Chinese chess game, the chesses of red side must face to the black side. In the same way, the chesses of black side must face to red side, too. The enhance A* searching algorithm can delete the turn numbers to decrease the total motion distance, and select all cross points from the programmed motion path to cut down redundant motion path in the rectangle region.

4. Experimental Result

We make an example to explain how to implement in Chinese chess game, use evaluation algorithm and artificial intelligence method to decide the moving chess with the highest evaluation score, and use enhance A* searching algorithm to program the shortest motion paths of the assigned chesses from the start positions to the target positions. There is a famous set to be called "wild horse run in farm" shown in Fig. 3.

There are eight chesses (one king, two elephants, two rooks, one horse, two pawns) in red side and nine chesses (one king, two advisors, two elephants, one rook, and three pawns) in the black side. Movement process of the set is belonging to the player and the supervised computer shown in Table.1 to be classified four steps. In the first step, the player moves red rook form (8, 5) to (8, 1). The motion path of the chess "red rook" is programmed using enhance A* searching algorithm. The movement scenario of the assigned chess is shown in left-up side of Fig. 4(a) on the user interface. The movement status of the mobile robot is instead of the assigned chess shown in Fig. 4(a). Then the computer moves the black advisor to protect the king from (5, 2) to (6, 1). The movement scenario of the assigned chess is shown in Fig. 4(b).

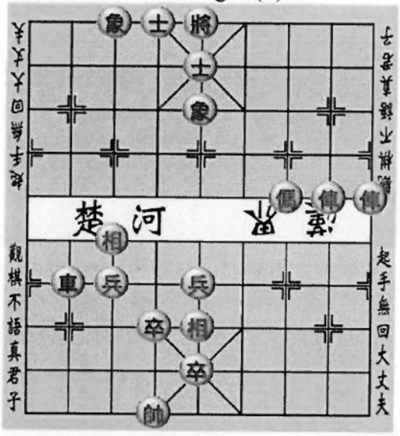

Fig. 3 A famous set "Wild horses run in farm"

The player moves the red horse to take the black king from the position (7, 5) to the position (6, 3), and the computer moves the black king from the position (5, 1) to (5, 2) in the second step. The movement process of the grid based platform is shown in Fig. 4(c) and (d). Each step of the computer must calculate the score of the moveable chesses shown in Table 1. Then the computer decides the optimal motion path of the selected chess. In the third step, the player moves the red rook from (8, 1) to (8, 2), and the computer moves the black elephant from (3, 1) to (1, 3) shown in Fig. 4(e) and (f). Then the black king will be taken by the red rook in the fourth step of the red side, and the game will be ending. The movement scenarios of two chesses (two mobile robots) are shown in Fig. 4(g). The motion paths of two mobile robots have collision problem in the case. The supervised computer must re-program the new motion paths to avoid the collision path. The black king is taken by the red rook, and moves to the assigned position 28. The set will be ending. The final arrangement positions of the remainder chesses shown in Fig. 4(h).

Table 1 Movement process of the assigned set

	Player (red side)	Computer (black side, using evaluation algorithm)	
		Movement process	Score
First step	Rook (8,5)→(8,1)	Advisor (5,2) →(6,1)	-295

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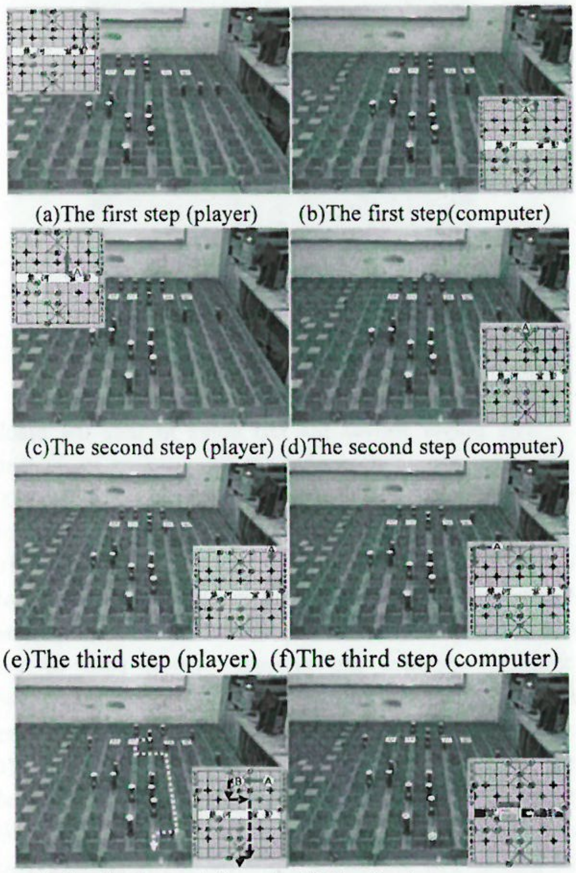
Second step	Horse (7,5) →(6,3)	King (5,1) →(5,2)	-18888
Third step	Rook (8,1) →(8,2)	Elephant (3,1) →(1,3)	-19991
Fourth step	Rook (8,2) →(5,2)		
Result	Winner		



(a)The first step (player) (b)The first step(computer)

(c)The second step (player) (d)The second step (computer)

(e)The third step (player) (f)The third step (computer)

(i)The final step (player) (j)The final arrangement

Fig. 4. Moving process for the set

5. Conclusion

The Chinese chess game system contained a supervised computer with the user interface, some wireless RF modules, a chessboard platform and thirty-two mobile robots. The computer can select moveable method of the assigned chess using evaluation algorithm and artificial intelligence method. We program the shortest motion paths of assigned chesses using enhance A* searching algorithm to obey the rule of Chinese chess game. The proposed methods can program two motion paths for two chesses, and solve the collision problem for multiple mobile robots moving on the chessboard platform simultaneously. We implemented a famous set to be called "wild horses run in farm" using the proposed method. The paper used the set to implement the evaluation algorithm, artificial intelligence method and enhance A* searching algorithm. The proposed methods are not only used in the Chinese chess game, but also applied in various game, and entertainment field, and manufacture process and production management. Further the moving process of mobile robots can be used in the simultaneous war using the proposed algorithms.

Acknowledgements

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References

1. P. Darwen and X. Yao, Coevolution in Iterated Prisoner's Dilemma with Intermediate Levels of Cooperation: Application to Missile Defense, *International Journal of Computational Intelligence Applications*, Vol. 2, No. 1, pp.83-107, 2002.
2. K. L. Su, B. Y. Li and C. Y. Chung, "Enhance A* Searching Algorithm Applying in Multiple Robot System," *Applied Mechanics and Materials*, Vol.479-480, pp.773-777, 2014.
3. K. L. Su, S. T. Su, K. H. Hsia and B. Y. Li, Implementation of the Chinese Chess Game with the Computer Using Artificial Intelligence, *International Journal of Research and Surverys, ICICExpress Letters, Part B: Applications*, Vol.7, No.6, pp.1353-1358, 2016.
4. T. Fu and H. Yin, Designing a hybrid position evaluation function for Chinese-chess computer game, *International Conference on Software Engineering and Service Science*, Beijing, China, pp.75-78, 2012.
5. Y. Saber and T. Senjyu, Memory-bounded ant colony optimization with dynamic programming and A* local search for generator planning, *IEEE Trans. on Power System*, Vol.22, No. 4, pp.1965-1973, 2007.
6. K. L. Su, B. Y. Li, J. H. Guo and K. H. Hsia, "Implementation of The Chess Game Artificial Intelligent Using Mobile Robot," *International Conference on Soft Computing and Intelligent System*, Kitakyushu, Japan, Dec. 3- 6, pp.169-174, 2014.
7. K. L. Su, B. Y. Li and C. Y. Chung, Enhance A* Searching Algorithm Applying in Multiple Robot System, *Applied Mechanics and Materials*, Vol.479-480, 2014, pp.773-777.

Design and Implementation of the SCARA Robot Arm

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Abstract

The article designs a four-joint SCARA robot arm using PLC-based control system. The control system (ASDA-SM) is all in one device to be produced by the DELTA Company, and contains four axis controllers and drivers. The robot arm contains four AC servomotors, four driver devices and a vision system. The PLC-based controller also programs motion commands of the gripper to finish the assigned tasks using Ladder Diagram (LG), Function Block Diagram (FBD), Sequential Function Chart (SFC), Instruction List (LL) and Structure Test (ST). Each driver has been tuned the parameters of the PID controller. The human machine interface (HMI) is a touch panel to be used for the robot arm. Users can control the motion path of any joint, and uses the DOPSoft language to design the human machine interface. In the experimental results, The SCARA robot arm catches a seal, and falls to stamp the assigned positions step by step, and identifies the precious of the robot arm, and moves eight objects to the assigned positions.

Keywords: SCARA Robot arm, PLC-based controller, AC servomotors, PID controller.

1. Introduction

How to find a fast and effective way to program the motion trajectory of the robot arm becomes an important problem. A robot arm is a mechanical device driven by some electronic motors, pneumatic devices or hydraulic actuators. A well-trained robot arm can help human to complete assigned tasks automatically. The purpose of the paper is to design and implement a four-degree-of-freedom SCARA robot arm. The robot arm is composed of four AC servomotors. In the control aspect, a PLC-based (ASDA-MS system) controller is used to control the robot arm.

There are some researches regarding the robot arm in the past. For example, Shafik et al. presented an innovative 3D piezoelectric ultrasonic actuator using flexural vibration ring transducer for machine vision and robot guidance applications [1]. Homayounzade et al. developed an observer-based impedance controller for robot arm during a constrained motion. The proposed controller required the measurements of link position and interaction force [2]. Sim et al. presented a binocular stereo vision to decide the desired location of the SCARA robot arm [3]. Kenmochi et al. proposed a motion control method based on environmental mode for a dual arm robot. By controlling mode information, particular features or trends can be given to the robot's motion. Then a distinctive complex motion can be realized [4].

In some conditions, the robot arm catches the assigned object using the feedback signal of the image system. Karthikeyan et al. presented a simple active tracking system, using a laser diode, a steering gear box setup and a photo-resistor, which is capable of acquiring two dimensional coordinate in real time without the need of any image processing technique [5]. Cao et al. designed a 5-DOF SCARA robot arm for welding, and built the model and the kinematic equations using D-H method [6].

2. System Architecture

The system architecture of the SCARA robot arm system is shown in Fig. 1. The system contains a computer, a PLC-based controller (ASDA-SM), a image system (Open CV), four AC servomotors, a solenoid and a gripper. ASDA-SM and four AC servomotors and a solenoid and a gripper integrate the SCARA robot arm. The solenoid drives the gripper to catch the assigned object.

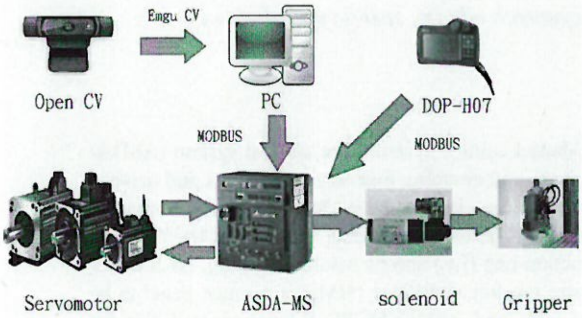

Fig. 1. System Architecture of the SCARA robot arm

The SCARA robot arm has four DOFs, (Degree of Freedom) to be shown in Fig. 1. The first and second joints rotate along the Z axis. The rotation radius of two joints is the same to be 205mm. the rotation angle of the first joint is $\pm 157^0$, and the second joint is $\pm 142^0$. The movement displacement of the third joint is 150mm. the rotation angle of the fourth joint is $\pm 180^0$. The specifications of the SCARA robot arm are shown in the table1.

The prototype of the controller (ASDA-SM) shows in the Fig. 3. We explain each function of the controller. "A" part is the communication port. The controller can use MODBUS, RS485 or RS232 interface to connect with the computer. "B" part can display the operation status and error codes. Four AC servomotors will connect with the part "C" of the controller. "D" part is the standard input and output terminal with digital signals. The limit positions of each servomotor connect with the part "E", and decide the moveable range of each joint. "F" part connect with the encoder of each motor as feedback signal and measure the real-time rotation angle. The power input is the "G" part. The arrangement method of the controller is shown in Fig. 4 with AC servomotors. The connection pin of the power system is shown in Fig. 5.

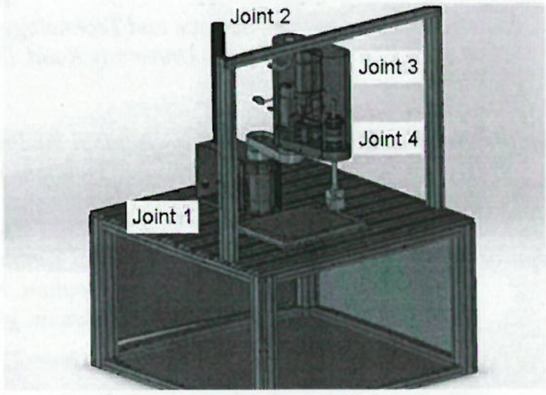

Fig. 2. Prototype of the SCARA robot arm

Table 1. Specifications of the robot arm

Functions	Joint	Range
Length of the robot arm	First joint	205mm
	Second joint	205mm
Rotation and displacement range	First joint	$\pm 157^0$
	Second joint	$\pm 142^0$
	Third joint	150mm
	Fourth joint	$\pm 180^0$

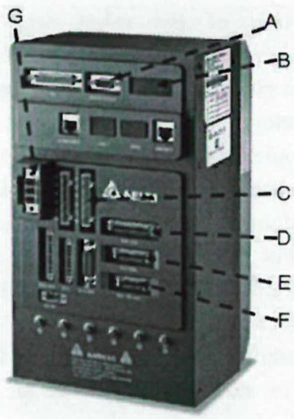

Fig. 3. The PLC-based controller(ASDA-SM)

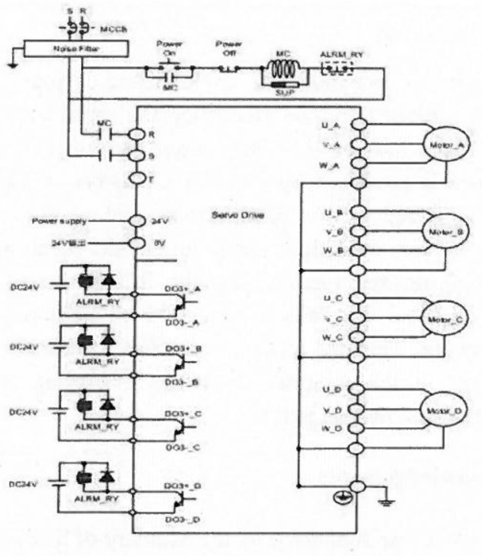

Fig. 4. Arrangement method of four servomotors

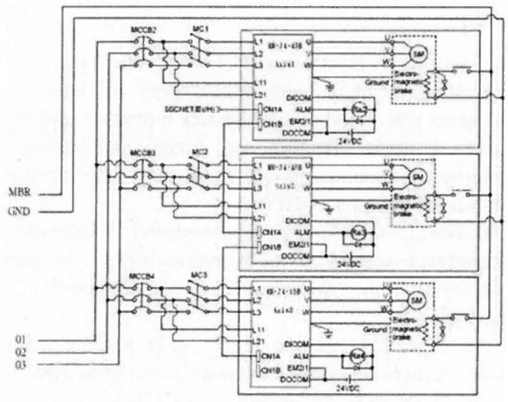

Fig. 5. The power connection method

In the assigned task, the SCARA robot arm can complete various assigned tasks such as coming and going on two points, moving multiple objects to the assigned positions and working on the multiple positions. Finally the robot arm can catch the color object moving to the assigned position according to the detection result of the image system..

3. Experimental Result

We implement the functions of the SCARA robot arm in two aspects. The robot arm catches a seal to stamp the seal on eight positions in the first experiment, and moves eight objects to the assigned positions in the second experiment.

In the first experiment, the robot arm executes catching a seal and stamps the seal on eight positions. The positions of the working space are shown in the right side of Fig. 6, and the relation distance of each working position is shown in the left side of Fig. 6. The robot arm must control the seal to stamp in the circle. The radius of the circle is 12mm. The robot arm programs a series trajectories using point to point control technology. First the robot arm moves to the initial position shown in Fig. 7(A), and catches the seal moving to the assign position "A", and falls to stamp the seal on the position shown in Fig. 7(B)-(D). Then the robot arm rises up and moves to the second position "B", and falls to stamp the seal on the assigned position shown in Fig. 7(E)-(H). The robot arm finishes the others step by step shown in Fig. 7(I)-(O). Finally the robot arm moves to the eight position, and falls to stamp the seal on the assigned position. Then the SCARA robot arm moves to the initial position and puts down the seal on the original position to stop shown in Fig. 7(P).

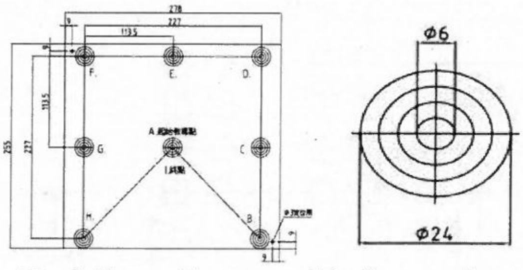

Fig. 6. The working space of the first experiment

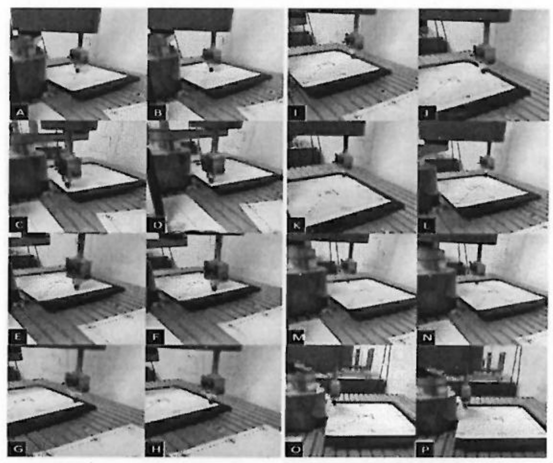

Fig. 7. The first experimental result

In the second experiment, the robot arm catches eight objects with the same size on the left side of Fig. 8, and moving to the right side with the same relation position. The size of each object is cube to be 1cm in length, width and height respectively. The robot arm programs a series trajectory using point to point control technologies, too. First the robot arm moves to the initial position shown in Fig. 9(A), and catches the first object on the right-up side. The object moves to the same position on the right side show in Fig. 9(B) and (C). Then the robot arm rises up and moves to the left-up position shown in Fig. 9(D), and catches the object moving to the assigned position shown in Fig. 9(E) and (F). And then the robot arm catches the others step by step, and moves and falls to the assigned position show in Fig. 9(M)-(Q). Finally the robot arm catches the last object on the left-down side and moves and falls on the assigned position show in Fig. 9(R) Then the robot arm moves to the initial position and stop.

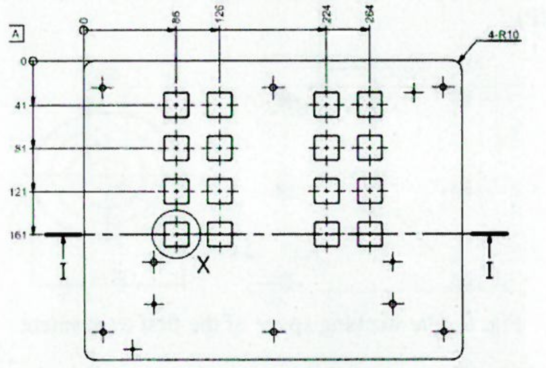

Fig. 8. The working space of the second experiment

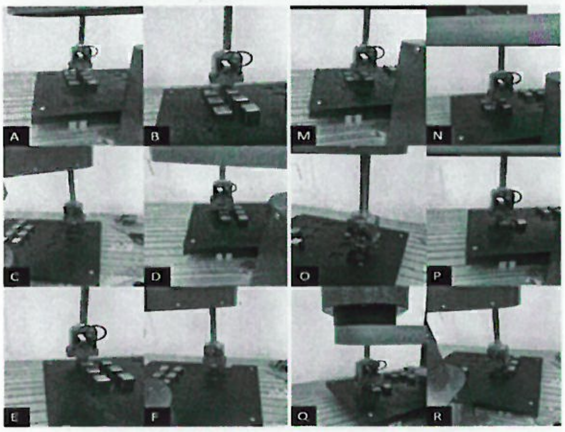

Fig. 9. The second experimental result

4. Conclusion

The papers designed and implemented a four joints SCARA robot arm, and controlled the robot arm using PLC based system. The PLC based system is ASDA-MS that is produced by DELTA Company in Taiwan. We calculated motion displacement and rotation angle of each joint from the inverse kinematic equations. In the experimental results, first the SCARA robot arm catches a seal, and falls to stamp the on eight positions one by one. Then the robot arm catches the eight objects moving to the assigned locations according to the programmed motion paths..

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References

1. M. Shafik, B. Nyathi and S. Fekkai: An innovative 3D ultrasonic actuator with multidegree of freedom for machine vision and robot guidance industrial applications using a single vibration ring transducer, *International Journal of Engineering and Technology Innovation*, Vol. 3, No. 3(2013), pp.168-179.
2. M. Homayounzade and M. Keshmiri: Observer-based impedance control of robot manipulators, *International Conference on Robotics and Mechatronics* (2013), pp.230-235,
3. H. S. Sim, Y. M Koo, S. H. Jeong, D. K. Ahn and B. N. Cha: A study on visual feedback control of SCARA robot arm, *International Conference on Control, Automation and System* (2015), pp.1268-1270.
4. T. Kenmochi, N. Motoi, T. Shimono and A. Kawamura: A motion control method of dual arm robot based on environmental modes, *IEEE International Conference on Mechatronics* (2013), pp.458-463.
5. R. Karthikeyan, P. Mahalakshmi and N. GowriShankar: Smart laser based tracking system for robotic arm, *International Conference on Communication and Signal Processing* (2013), pp.903-907.
6. F. Cao, J. Chen, C. Zhou, Y. Z. Zhao, Z. Fu and W. X. Yan: A novel 5-DOF welding robot based on SCARA, *International Conference on Industrial Electronics and Applications* (2015), pp.2016-2019.