

ISBN : 978-1-5386-0548-6



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2017 4th International Conference on Electrical, Computer Science and Informatics

September
19-21, 2017

Grand Mercure
Yogyakarta, Indonesia

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**2017 4th International Conference on Electrical Engineering,
Computer Science and Informatics (EECSI)**

19-21 September 2017, Yogyakarta, Indonesia

Editors:

Munawar A Riyadi

Mochammad Facta

Deris Stiawan

Hatib Rahmawan

Proceedings

2017 4th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI)



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ISBN : 978-1-5386-0548-6 (PRINT, Part Number : CFP17B51-PRT)

ISBN : 978-1-5386-0547-9 (DVD Part Number : CFP17B51-CDR)

ISBN : 978-1-5386-0549-3 (XPLORE COMPLIANT, Part Number : CFP17B51-ART)

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PROCEEDINGS

**2017 4th International Conference on Electrical Engineering,
Computer Science and Informatics (EECSI)**

19-21 September 2017, Yogyakarta, Indonesia

Editors:

Munawar A Riyadi

Mochammad Facta

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Proceedings

2017 4th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI)



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ISBN : 978-1-5386-0548-6 (PRINT, Part Number : CFP17B51-PRT)

ISBN : 978-1-5386-0547-9 (DVD Part Number : CFP17B51-CDR)

ISBN : 978-1-5386-0549-3 (XPLORE COMPLIANT, Part Number : CFP17B51-ART)

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Parameterized Kick Engine For R-SCUAD Robot

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Abstract—Humanoid Robot Soccer is an implementation of technology in robotics area that has the ability to mimic human activity to play football. Kicking is one of many abilities that the robot must have to play football nicely. The ability to kick in a various kind of kick also needed to enhance it's performance in the match. This research was conducted on a 20 degree of freedom humanoid robot soccer named R-SCUAD. The robot was equipped with 20 Dynamixel servo motors as the actuator, an arbotix-pro as a sub-controller and an Odroid XU4 as the main controller. The method developed in this research was based on Darwin-op framework with an enhancement especially on the kick engine. Experiment results showed that there was a correlations between the distance that the ball travelled due to a kick with leg the swing speed of the kick, it can be inferred that a greater swing speed value will yields a greater distance of ball travel. With the leg swing speed of 50 rpm generate average distance 36.58 cm while with a speed of 300 rpm generate an average distance of 329.62 cm. Result also showed that the balancing system developed based on kick angle computation was able to maintain the robot stability up to 25° of kick angle.

Keywords; *Forward kinematics; Humanoid robot soccer; Parametric kick;*

I. INTRODUCTION

Indonesian Robocup Soccer Humanoid League was the new title for Kontes Robot Cerdas Indonesia (KRCI) *Robo Soccer Humanoid League* (RSHL) that became an event to select Indonesia's representative for the Robocup International yearly event. *Humanoid Robot Soccer* was a form of technological implementation in the robotic field that has the ability to mimic human's activities in playing football/soccer. [1].

The robot also must posses an ability to "hear" referee's instructions, in this case using a wifi network communication system. The robot must have the ability to percept the field and all form of object that may present on the field. The Robot must walk on biped while maintaining its balance so it can locomote reliably. Many researchers try to cope this problem in their research, such as [2-6]. Those research aimed to have a better walking capabilities for the robot. This research mainly based on the research of Darwin-op framework [2], that propose an approach to have a robot that has the ability to

walk, kick and do some kind of movement based on input from the USB camera attached to the robot.

To achieve those kind of abilities, the robot equipped with a configuration of component and hardware that enable the robot to move freely and achieve high level of dynamics. Inside the robot's torso an embedded pc was placed as the main controller, the sub controller was stacked on the main controller. As the actuation the robot uses 20 pieces Dynamixel servo, webcam was used as the vision sensory input to get information from its surrounding. A 3 axis Gyroscope and 3 axis accelerometer also attached to the robot as its internal state sensory input. This research was focused on how to develop a parametric kick engine that enables the robot to has an infinite variations of kick motion. The Darwin-op framework already has an ability to do kicking motions, but it uses a prerecorded handcrafted motion. In other word we would have to create every single type of kick or motion manually by hand, if we want to have a variety of kick. It was a very time consuming task to craft this kind of motions because we need to manually adjust the positions of every joint, record those position as pose, proceeded with altering some joint to have a movement, record as another pose, one after another and save those pose as a motion that could be called to be playback on the future.

This research was motivated by the need to develop a kick engine that not involving handcrafting a kicking motions as the original Darwin-op framework did. Ferreira Rui, [7] has done a research titled *Development of an Omnidirectional Kick for a NAO Humanoid Robot* in which the developed kick engine consist of 5 phase.

- **Lean_Phase** – This is when the robot shifts its center of mass onto support leg.
- **Raise_Phase** – Phase where the robot raises the kick foot off the ground.
- **Kick_Phase** – When the robot kicks the ball. This is the main phase.
- **Return_Phase** – Phase when the robot return the leg without putting the foot on the ground
- **UnRaise_Phase** – This is when the robot shifts its center putting the kick foot on the ground.

II. RESEARCH METHODOLOGY

A. Hardware Configuration

Generally speaking, the robot consist of *main control*, *sub control* and *actuator*, the robot's block diagram presented on figure number 1 below :

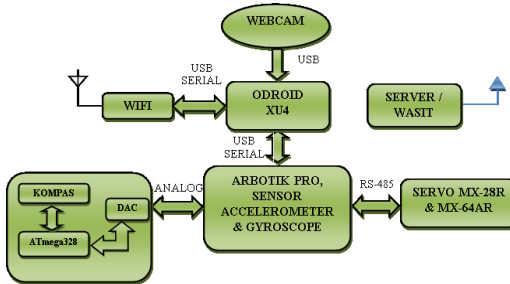


Figure 1 Robot's Block Diagram

The main controller was the Odroid XU4. It is an ARM based single board computer with a Samsung Exynos5422 Cortex-A15 2Ghz and Cortex-A7 Octa core CPUs as the main processor. We use Linux Ubuntu 14.04 for this research and C++ for the main programming language. OpenCV also installed on the main controller to utilize the library for the robot's vision system. Linux and android operating system for this board was made available by hardkernel as the creator of the board. As for the subcontroller we use a STM32 based controller, equipped with 3 axis gyroscope and 3 axis accelerometer and also the necessary circuitry needed to communicate to the Dynamixel MX series digital servomotor as the actuator. There R-SCUAD Robot used in this research, as shown in figure 2, use two kind of Dynamixel MX-series. The MX-64 and MX-28 series.

DYNAMIXEL (DXL) is a line-up of networked actuators for robots developed by a Korean manufacturer ROBOTIS. ROBOTIS is also the developer and manufacturer for DARwIn-OP[8]. DXL is being used by numerous companies, universities, and hobbyist due to its versatile expansion capability, powerful feedback functions, position, speed, internal temperature, input voltage, etc. It has a simple daisy-

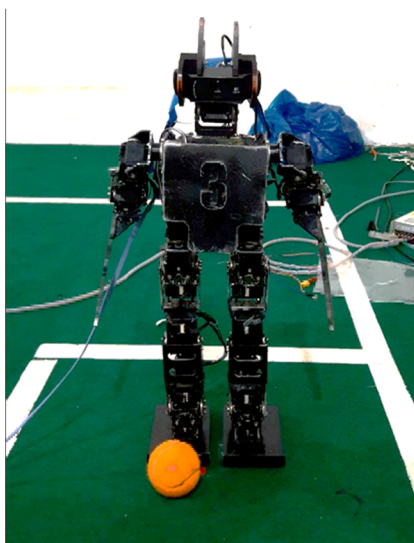


Figure 2 R-SCUAD Robot

chain topology for simplified wiring connections.

DXL can be used for multi-joint robot systems such as robotic arms, robotic hand, bi-pedal robot, hexapod robot, snake robot scorpions, pan tilts, kinematic art, animatronics and automation, etc. Dynamixel is an actuator controlled by digital packet communication (protocol communication). User could send an instruction packet, in serial form, and the dynamixel will respond to the instruction accordingly.

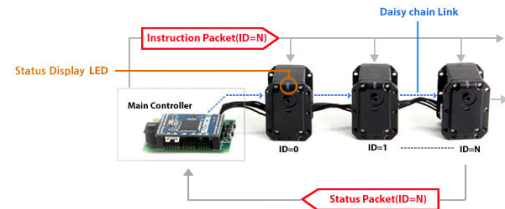


Figure 3 Dynamixel Communication Protocol

B. Software Configuration

The kick engine was developed based on forward kinematics, i.e. the system supplied with the joint position information and the final position of the link, the leg in this case was obtained. Simple balancing system based on the relation between kick angle and hand angle was added to kick engine. The balancing system will compute the necessary arm movement to encounter to force generated from opening the leg. The flowchart for the developed kick engine for the R-SCUAD can be depicted on the figure 4., below.

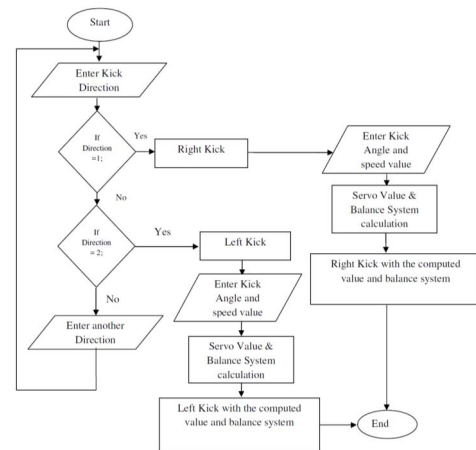


Figure 4 Flowchart of the developed kick engine

A kick consist of 5 phase that must be completed to have a kick.

- Lean
- Raise
- Kick
- Return
- UnRaise

Those stages can be depicted below

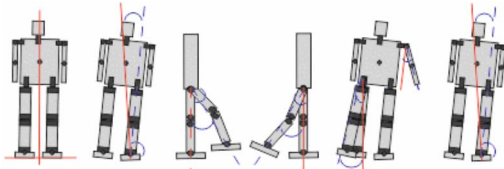


Figure 5 Kick Phase

III. RESULT AND ANALYSIS

There were two kind of testing in this research, first a test to verify distance traveled from a various kick swing speed, and the second was test to verify the robot stability for a numerous kind of kicking motions.

A. Ball Travel

As mentioned beforehand a kick consist of 5 phase, the implementation of those 5 phase can be seen on figure no 6 below

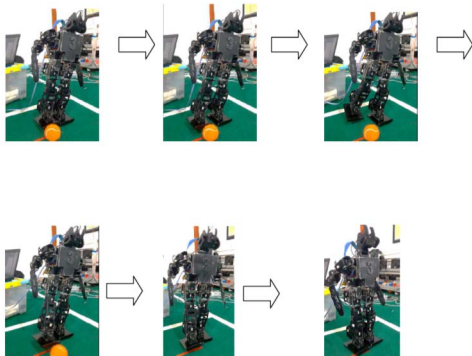


Figure 6 Kick Implementation

To verify that the kick engine developed has a controlling ability for ball travel distance, we conducted a series of test with the variation of kick swing speed. The result showed the relations between kick swing speed with the ball travel distance can be seen in figure 7 below

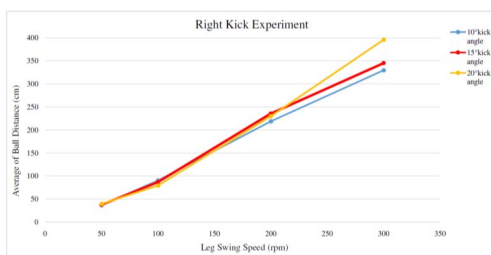


Figure 7 Ball Travel and Kick Speed

It can be inferred from the graph that the robot could control the ball travel distance proportionally with the kick swing speed for any given kick angle. Robot was able to kick the ball up to 3 m distance using 300 rpm kick speed.

B. Balancing Ability

The balancing test was conducted using variation of kick angle and swing speed parameter. The parameter will be used as reference on how far the balancing system able to maintain the robot in standing position, i.e. not fall. There are two kind of test here, right kick and left kick. As mentioned earlier the balancing system was implemented simply using the kick angle, how far is the kicking leg opened from its normal position. This value will be used to determine how far the arm will move or opened to encounter the leg movement. This process is done synchronously while opening the leg.

Data collected for 10°, 15°, 20°, 25° and 30° kick angle with 50, 100, 200, and 300 rpm kick speed, the result shown in figure no 8. below.

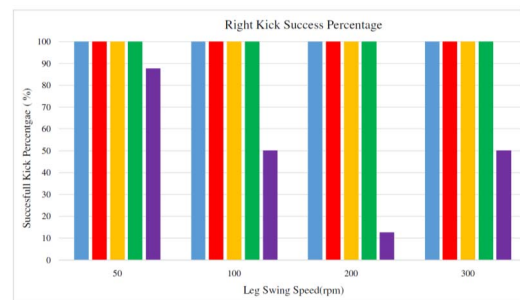


Figure 8 Successful Kick Percentage (Right kick)

It can be seen from the graph that regarding right kick the robot has a very high percentage of successful kick motion for all kick swing speed, however there is a decrease in this percentage when we give a wider kick angle, in this case 30°.

Same procedure was taken for the left kick motion, the arm opening was done synchronously with the leg opening to maintain the robot's balance.

Data collected for 10°, 15°, 20°, 25° and 30° kick angle with 50, 100, 200, and 300 rpm kick speed, the result shown in figure no.8 below.

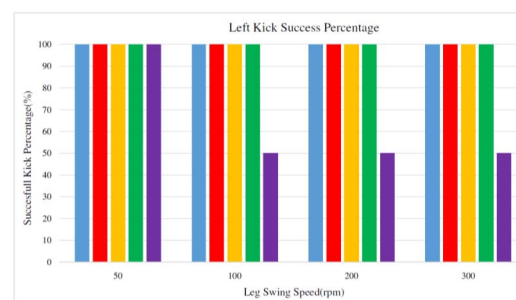


Figure 8 Successful Kick Percentage (Left kick)

It can be seen from the graph that regarding left kick the robot has a very high percentage of successful kick motion for all kick swing speed, however there is a decrease in this percentage when we give a wider kick angle, in this case 30° .

IV. CONCLUSION

Based on experimental result, conclusions below could be inferred:

Kick variations were able to be implemented in the form of kick angle and kick swing speed parameter, these parameter were proportionally related to ball travel distance due to the kick. It were verified using 10° , 15° and 20° kick angle and 50, 100, and 200 rpm kick swing speed. The faster the kick swing the further the ball traveled. The developed balancing system was based on arm angle computation algorithm. The system was able to maintains the robot balance when performing a kicking motions. The developed balancing system still unable to guarantee a 100% seccessful kick for 30° of kick angle. Gyroscope and Accelerometer stabilized kick engine should be investigated in the future to enhace the robot balancing ability when performing a kicking motions.

Acknowledgment

The research was funded using Universitas Ahmad Dahlan Robotic team grant.

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Maulidevi, Nur Ulfa	D2RA.5	451	Prakoso, Teguh	D1RB.16	176
Mestari, Mohammed	D2RB.1	513		D2RC.5	614
	D2RB.7	544	Pramunanto, Eko	D1RE.15	418
Mohd Rahim, Mohd Shafry	D1RC.14	244	Pranowo, Pranowo	D1RE.16	424
Mohd Saad, Norhashimah	D1RC.4	196	Praptodiyono, Supriyanto	D2RC.12	653
Monemi, Alireza	D1RA.10	55	Pratama, M. Ardhika	D1RA.9	49
Muhimmah, Izzati	D2RA.1	430	Pratama, Rizki	D1RE.12	405
Munir, Munir	D1RD.6	289	Prihatini, Rahayu Suci	D1RC.8	218
Muqorobin, Anwar	D1RE.8	383	Priyandoko, Gigih	D1RC.14	244

Pujotomo, Isworo	D1RE.2	358	Sanou, Ibrahim	D2RB.1	513
Purnomo, Mauridhi	D1RE.15	418	Santoso, Albertus	D1RE.16	424
Purnomo WP, Yohanes Sigit	D2RA.13	487	Saputra, Wardianto Eko	D2RD.15	751
Purwadi, Agus	D1RE.8	383	Sari, Christy	D1RC.2	187
Purwiyanti, Sri	D1RE.14	414	Sari, Widya	D1RB.14	165
Putri, Hardika	D2RC.13	658	Sarno, Riyanarto	D1RD.1	261
Putro Sarwo Setyohadi, Dwi	D1RA.6	35		D1RD.9	306
				D1RD.15	336
Qonita, Adiba	D2RD.14	746		D1RD.16	341
				D2RA.8	466
Rachik, Mostafa	D2RB.1	513		D2RD.2	678
	D2RB.7	544		D2RD.3	684
Rachman, Anung	D1RC.9	223	Satria, Haikal	D1RB.11	150
Rachmawanto, Eko	D1RC.2	187	Satria, Muhammad	D2RC.10	642
Rachmawati, Ema	D1RC.5	202	Sembiring, Jaka	D1RD.14	330
Rahardjo, Budi	D2RC.2	600		D1RD.17	347
Rahman, Arif	D1RC.6	208	Sensuse, Dana	D2RD.4	690
Rahmawati, Dewi	D1RD.16	341		D2RD.8	713
Raja Lope Ahmad, Raja Mohd Tariqi	D1RD.12	324	Setiadi, De Rosal Ignatius Moses	D1RC.2	187
Ramadhan, Arief	D2RD.8	713	Setiadi, Haryono	D2RD.12	735
Ramadiani, Ramadiani	D1RB.9	138	Setiadi, Herlambang	D1RE.9	389
Ramli, Kalamullah	D1RB.3	110	Setianingrum, Anif	D1RC.8	218
Rantelinggi, Parma	D2RC.1	596	Setiawan, Agung	D1RC.16	256
Resha, Muhammad	D2RA.10	477	Setiawan, Joga	D2RB.9	556
Retnowardhani, Astari	D2RA.9	472	Setyawan, Arinto	D1RE.14	414
Riadi, Imam	D2RA.6	456	Setyohadi, Djoko	D1RD.3	271
Riandini, Riandini	D1RB.13	160		D2RA.13	487
Riskiawan, Hendra	D1RA.6	35	Sfenrianto, Sfenrianto	D2RD.7	708
Riyadi, Munawar	D1RB.16	176	Shaikh-Husin, Nasir	D1RA.7	39
	D2RC.5	614	Shepeta, Alexander	D2RC.3	605
Rizaldi, Taufiq	D1RA.6	35	Shofi, Imam	D1RC.8	218
Rochmanto, Raditya	D1RB.7	129	Sirkunan, Jeevan	D1RA.7	39
Roseno, M	D2RB.5	535	Sitohang, Benhard	D2RD.10	723
Rosyadi, Ahmad	D1RB.2	104	Soewito, Benfano	D1RA.8	44
				D1RD.10	313
S, Muhammad	D2RA.7	461		D2RA.3	441
Sabatini, Gabriella	D2RA.13	487		D2RB.12	573
Saha, Diganta	D1RA.16	94	Sofhan, Rian	D2RC.12	653
Sahrizal, Ahmad	D2RA.17	507	Sonnadara, Upul	D1RC.7	212
Saleem, Muhammad Mubasher	D2RC.6	619	Sorokin, Alexander	D2RC.3	605
Samra, Ahmed	D2RC.14	664	Stiawan, Deris	D1RA.4	25
Sanmorino, Ahmad	D1RD.2	267	Subhiyakto, Egia	D1RC.13	239
			Subrata, Aan	D1RD.14	330

Subroto, Imam Much Ibnu	D2RD.15	751	Wan Abdul Ghani, Wan Safra	D1RD.5	283
Sucahyo, Yudho	D2RD.4	690	Diyana		
Suhardi, Suhardi	D1RD.14	330	Wan Ismail, Wan Basri	D1RD.12	324
	D1RD.17	347	Wanandi, Krisantus	D2RB.12	573
Suharyanto, Cosmas	D1RA.8	44	Wattimena, Gysberth	D2RC.3	605
Suhendi, Dede	D1RE.10	395	Watulingas, Jefferson	D2RC.11	647
Sujanarko, Bambang	D1RB.2	104	Wibawa, Aji	D1RD.6	289
Sukur, Muji	D1RC.10	228	Wibowo, Moh	D1RC.6	208
Sulistiyantri, Sri	D1RE.14	414	Wibowo, Nur	D1RD.3	271
Sulistyorini, Yunis	D1RE.7	377	Widianto, Widianto	D1RE.4	362
Sungkono, Kelly	D2RD.3	684	Widiyaningtyas, Triyanna	D1RA.9	49
Suprpto, Yoyon	D1RB.15	170		D2RD.14	746
Supriana, Iping	D1RC.5	202	Widiyanto, Andi	D2RB.6	540
	D2RA.5	451	Widodo, Nuryono	D2RB.4	531
Surjati, Indra	D2RC.4	610	Widyantoro, Dwi	D2RD.5	696
Suroso, Jarot S	D2RA.9	472	Widyarto, Setyawan	D1RB.14	165
Suryasa, Nyoman	D1RC.14	244		D1RC.14	244
Suryawan, Fajar	D2RB.15	590		D1RD.12	324
Suryono, Suryono	D2RB.11	567		D2RA.2	436
Susiki Nugroho, Supeno Mardi	D1RD.6	289	Wijaya, Oky	D1RA.8	44
	D2RA.15	498	Winarko, Edi	D1RC.6	208
Sutikno, Tole	INV.1	1		D1RD.7	294
Suwarno, Dr	D1RE.6	371	Winarno, Edy	D1RC.10	228
Suyadi, Suyadi	D1RE.3		Winiarti, Sri	D2RA.1	430
Syaifudin, Yan	D1RA.1	9	Wiryadinata, Romi	D2RC.8	631
Syed-Yusof, Sharifah	D2RC.10	642	Wu, Hsien-Tsai	D1RB.8	134
Tahyudin, Imam	D2RD.11	729	Yacoub, Redi	D1RE.12	405
Talib, Shukor	D1RB.11	150	Yang, Chieh	D1RB.8	134
Tan, Tse Guan	D1RD.5	283	Yani, Irsyadi	D1RA.5	30
Taufik, Mohammad	D1RE.9	389	Yani, Irsyadi	D2RB.14	584
Tjahjadi, Hendrana	D1RB.3	110	Yel, Mesra	D2RD.7	708
Tjahjadi, Martinus	D1RC.1	181	Yohanes, Banu	D2RC.7	626
	D1RE.13	409	Yovita, Leanna	D2RC.13	658
Tutkun, Nedim	D1RE.7	377	Yuliani, I Dewa Ayu Eka	D1RD.11	319
			Yuliansyah, Herman	D2RA.1	430
Ungkawa, Uung	D2RD.5	696	Yulita, Intan	D1RA.15	88
Utama, Yoga	D2RB.8	550	Yunianta, Arda	D1RD.8	300
Utami, Ema	D2RD.13	739	Yusa, Mochammad	D2RD.13	739
			Yusuf, Yushan	D1RE.11	399
Vedyanto, Vedyanto	D1RD.11	319	Zaini, Ahmad	D1RB.15	170
			Zawawi, Khoirunnisya	D1RA.14	82
Waluyo, Catur	D2RC.9	637			

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