KUDOS Team Description Paper
for Humanoid Adultsize League of RoboCup 2016

Hojin Jeon, Donghyun Ahn, and Baek-Kyu Cho

Robotics and Control Laboratory
Dept. of Mechanics and Design, Graduate School of Kookmin University, KOREA
E-mail:baekkyucho@kookmin.ac.kr
Web:http://rclab.kookmin.ac.kr
http://kudos.kookmin.ac.kr

Abstract. We will participate in adult size league by using our new robot, KMU Humanoid Prototype-1(KHP-1). With previous RoboCup and Darpa Robotics Chanllenge's experience, we aim to excel in the competition.

Keywords: KUDOS, Humanoid Robot, Walking pattern generator, SLAM

1 Introduction

We are not only participating RoboCup, but also running several relevant humanoid researches, development and participation like Lower limb exoskeletal robotic system, Darpa Robotics Challenge, walking pattern of biped humanoid robot and development of humanoid robot platform. In particular, there is a lot of research of humanoid robot walking in our lab. Typically, push recovery, hopping, and running of humanoid robot have been proceeded.[1] [2]

After RoboCup2015, we started developing our new adultsize robot, KHP-1. And we applied walking and vision algorithms for robocup. The vision algorithm was developed by object recognition using exposure and contour. Also localization has been implemented through the landmark recognition. A walking algorithm has created a center of mass(CoM) trajectory using the optimal control called Preview control and it was confirmed as effective when our prototype was able to stably walk through experiments on surfaces such as grass.

2 Hardware

KHP-1 uses pulley, motor driver, harmonic drive and ft sensor for maintaining robot's limbs. The processor uses 2 intel's NUCs for vision processing and motion control.

Fig. 1. relevant humaoid researches in our lab

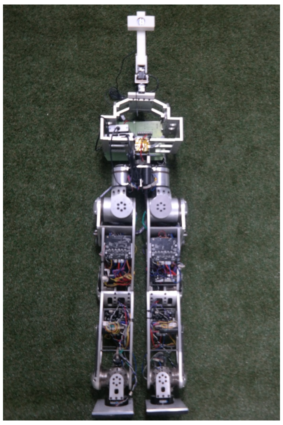

Fig. 2. Kubo's hardware

Table 1. KUBO's Hardware specification

Name	KMU Robot Prototype -1 (KRP-1)
Height	139cm
Weight	35kg
Number of DOFs	14 in total (6 Dof Legs x 2 + 2 Dof Head)
Actuator	maxon DC motor, Faulhaber DC motor, Dynamixel MX-28
Controller	Main Control Unit : D54250YWK, NUC5i5RYK Motor Controller : 2ch DC motor Controller
Camera	Logitech C920
Sensor	3 axis IMU, 3 Axis F/T sensor
Battery	25.9V Li-ion

3 Locomotion

KHP-1 is using the Preview control. [3][4] Preview control is the optimal control method that can calculate center of mass(CoM) of the robot when we know the zero moment point(ZMP). Performance index used for the preview control is defined as follows.

$$J = \sum_{i=k}^{\infty} \left\{ Q_e e(i)^2 + \Delta x^T(i) Q_x \Delta x(i) + R \Delta u^2(i) \right\} \quad (1)$$

Input u is the value to set the performance index to a minimum. and it is applied to the dynamic equation of the robot. For Matlab simulation, we can confirm the CoM trajectory established from the Preview control.

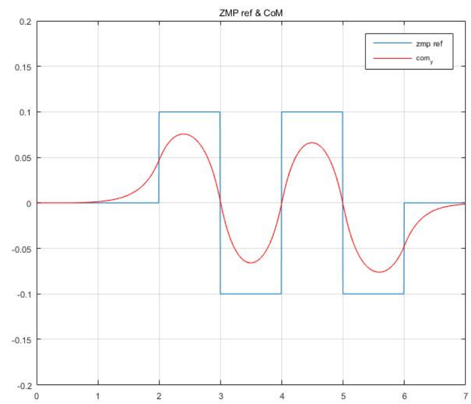

Fig. 3. The COM and ZMP trajectory when the robot move to five steps

4 Vision

For our team, major problem in revious years was recognition of lines on the ground. Lines and goalpost were most important data for localization. At the competition, lines on the ground were so easily erased. Because of this, we could only use the goalpost data for localizaion and result was disappointing. But unlike kid-size robot, this problem is not serious for adult-size. Because our robot, KHP-1's odometry is very accurate, we can use odometry data for localization. And minor problem was slow ball recognition algorithm, which used a SURF algorithm. To replace this, we have implemented a new algorithm which uses a camera's exposure data and contour. For example, to recognize a Ball, by adjusting camera's exposure, it achieves bright and dark zones in green field. Using this algorithm, the robot can now recognize a designated object on the ground.

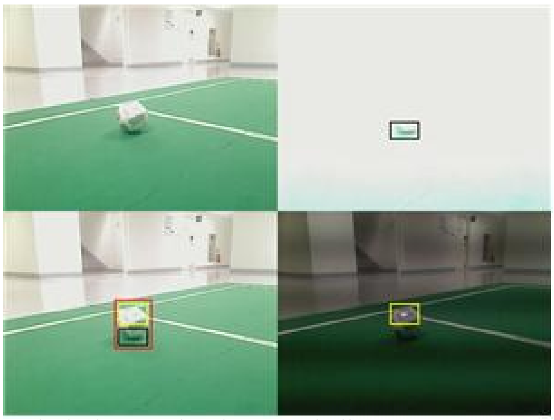

Fig. 4. original, dark zone, bright zone, ball recognition image in clockwise

5 Localization

We have implemented a slam for adult-size robot. Since our robot's odometry data is very accurate, there is no need to use a many particles and gaussian noise for Robot's Position. For landmark, we use the goalpost's pillar and two obstacles in field[5]. To get observation data, we use two method. One is distance estimation algorithm we implemented for Robocup2014 [6], and another is so called "bird's eye of view"[7]. By combining this data appropriately, we can get good observation data. From this data, we can draw a potential field map and decide a path from it.

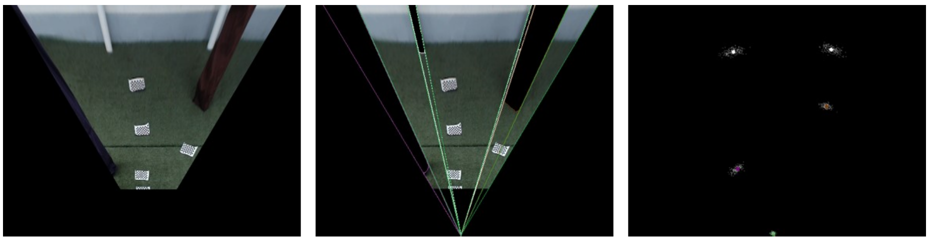

Fig. 5. BEV, observation image and map from it

6 Conclusion

We have participated for three years in a row in the Robocup competition as well as the Darpa Robotics Challenge final 2015 as DRC-HUBO Team. So we want to try to challenge the adult-size league based on these past experiences. KHP-1 is our new robot and applied to our own algorithms of the walking and vision.

While we have considerable preparation ahead of us, we are confident we will be ready will be ready for Robocup 2016 held in Germany. We are excited to face the challenge of the competition, and we are confident of a strong performance.

References

1. Baek-Kyu Cho, Sang-Sin Park, Jun-Ho Oh, “Stabilization of a hopping humanoid robot for a push”, 2010 10th IEEE-RAS International Conference
2. Baek-Kyu Cho, Jung-Hoon Kim, Jun-Ho Oh, “Online balance controllers for a hopping and running humanoid robot”, Advanced Robotics, 2011 , vol.25 , no.9-10 , 1209-1225
3. Tohru Katayama, Design of an optimal controller for a discrete-time system subject to previewable demand, Prentice Hall, INT.J.Control, 1985, vol.41, no.3, 677-699
4. Shuuji KAJITA, Biped Walking Pattern Generation by using Preview Control of Zero-Moment Point, September 14-19, 2003
5. Sebastian Thrun, Wolfram Burgard, Dieter Fox, Probabilistic Robotics, MIT Press, 2005
6. Hojin Jeon, Ju Seong Shin, Donghyun Ahn, Jihyun Park, Seunghun Lee, InWon Cho, SeRi Lee, Yeunhee Kim, Wanjin Kim, Jiwon Park, Jaewan Kim, Geunchang Jung, Sangmi Lee and Baek-Kyu Cho, KUDOS Team Description Paper for Humanoid Kidsize League of RoboCup2015, 2015.
7. Gary Bradski, Adrian Kaehler, Learning OpenCV: Computer Vision with the OpenCV Library, O’Reilly Media, 2008, 408-414