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Gait motion of a six legged real robot employing associatron

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Abstract: In this study, we have proposed gait motion algorithm of a six legged robot in order to walk an unpredictable irregular field. The algorithm is adapted to the Associatron. The algorithm has a property that enables the robot to recall an entire pattern from partial information, sequentially. Therefore, the robot can walk in unknown field. First, we verified the proposed algorithm by simulations using ODE (Open Dynamics Engine). It is clear that memorized pattern is recalled from unknown pattern. Secondly, an experiment is performed using the developed real robot. The experiment result proved that the robot is able to select suitable gait motion at the existence of an obstacle.

Keywords: gait motion, real legged robot, Associatron.

1 INTRODUCTION

Legged robots are focused on, because they are able to move in irregular or unpredicted field flexibly [1]. However, the control of the robot is difficult. A lot of researchers study various methods that enable legged robots to walk unpredictable irregular field such as the stricken area. For example, there are mimics insect[2], using neuron[3], subsystems[4], and CPG which is modeled in non-linear trembler system[5]. The other method to walk of the unpredictable irregular field is known as a tire-type, a crawler-type and etc. The one of the advantage of the legged robot is that it can move a center of gravity, and that it can stabilize posture [6].

We have proposed gait motion algorithm of a six legged robot using the property of the Associatron[7][8]. One of the properties of the Associatron is that it can recall an entire pattern from partial information. A mechanism of the memory of the robot is similar to one of an animal. We focus on the Associatron that is associative memory model. The aim of this paper is to implement the gait motion by using the Associatron to the robot. Moreover, the proposed gait motion is applied to a real robot. The validity and possibility of the algorithm are confirmed by simulations and an experiment.

2 SYSTEM

Assume that the robot has six legs, six touch sensors and a position sensing detector (PSD). We deal with static gait motion. The robot is shown in Fig. 1. The size and weight of the robot are 359 x 233 x 313 mm and 2.011 kg (include batteries), respectively.. The robot is similar to an insect. To simplify the discussion, the each leg unit has two actuators. They enable the each leg swing to roll (up-down) and yaw (front-back) direction, respectively. The each touch sensor is installed on each leg in order to detect ground. The PSD sensor is put on the front of the robot to measure the distance between own position and an obstacle. The model numbers of the PSD and the actuator are GPY0A21YK and KRS-784 ICS, respectively.

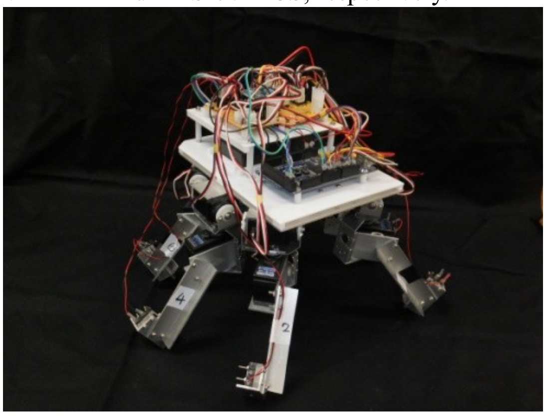

Fig. 1 A six legged robot

3 ASSOCIATIVE MEMORY

First, abstract of the Associatron is introduced. Secondly, proposed algorithm is described. Finally, the motion that we expect is shown.

3.1 Associatron

We adopt the Associatron[9] to the robot. The Associatron is a model for associative memory with a neural network structure. Then, it is a kind of memory algorithm that is similar to animal' s brain. The property of the Associatron that we utilized is that it can recall an entire pattern from partial information, especially.

Moreover, the orthogonal method of the Associatron [10] is adopted in order to prevent interference.

3.2 Algorithm

We describe the method that the Associatron is applies to gait algorithm. It is possible to recall next angles of all leg from the current angles, touch sensor information and measured distance. The reason is that the Associatron enables to recall the entire pattern from partial pattern.

In order to employ it to the robot, the memorized pattern is divided into present state and next state. The divided pattern is shown in Fig. 2. The memory size is 24 x 24. Gray region means current information (leg's angle, touch sensor state, and distance from obstacle). White one is next angles of the legs. We investigate whether the robot can recall the memorize pattern from unknown or the partial pattern in Sec 4.1.

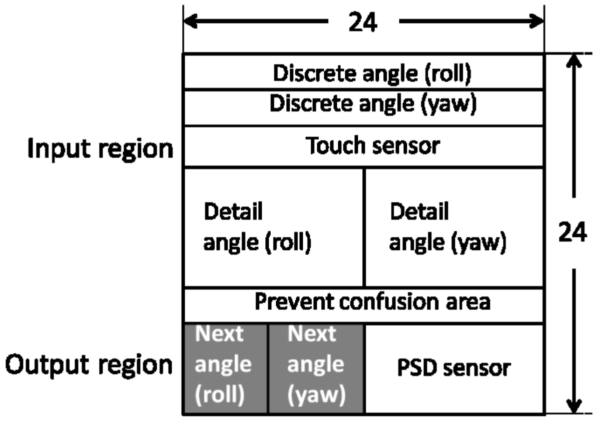

Fig. 2 Structure of the memorized pattern

3.3. Multiple gait motions

The robot must learn multiple gait motion corresponding to various irregular fields. And, the robot has to select the appropriate pattern of the movement, automatically. We consider the case that the Associatron memorized two type motions. The patterns are shown in Fig. 3. One is forward gait motion, when there is no obstacle in front of the robot (black blocks). First, the robot recall the F1.Secondly, it recall F2. Next, F3 and F4 are recalled in sequence. And, the F1 is recalled again. The other is turning gait motion, when there is obstacle (white blocks). Each pattern is repeated, if the value of the PSD sensor that is mounted in the front of the robot is not changed. It is expected that the movement of the robot change another gait motion by existence of obstacle.

Suppose that the robot faces the obstacle, after walking in no obstacle area. In this time, the pattern becomes incomplete. The region of the PSD sensor becomes the values of the obstacles, however the other region remains the pattern of moving forward. Then, we predict following steps:

1.Iincomplete information is recalled (F'-3)

2. Complete information is recalled (T1)

The selecting motion is confirmed by simulations (Sec. 4), and by an experiment (Sec 5).

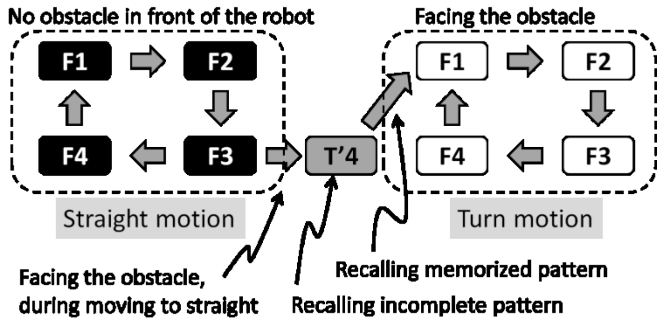

Fig. 3 Selection of the pattern

4 SIMULATION

We verify the proposed algorithm by ODE (Open Dynamics Engine) simulator. ODE is an open source physical simulator[11]. The parameters (weight, size, torque of the actuator and characteristic of the PSD) are same as the real robot.

4.1 Recall the memorized pattern

We confirm whether the robot can recall the memorized pattern from unknown ones. The robot memorizes the eight patterns that are shown in Fig. 3. In the simulations, one hundred different initial poses of the robot is tried. Two initial poses of the robot are illustrated in Fig. 4. Fig. 5 shows the results. Horizontal axis is step. "Step" depicts the number of the recall. Vertical axis means the similarity of the memorized pattern. "100 %" means that the recalled pattern agrees with memorized pattern. The robot can recall the memorized pattern within 10 steps from all performed cases.

It is confirmed that memorized pattern is recalled from unknown pattern.

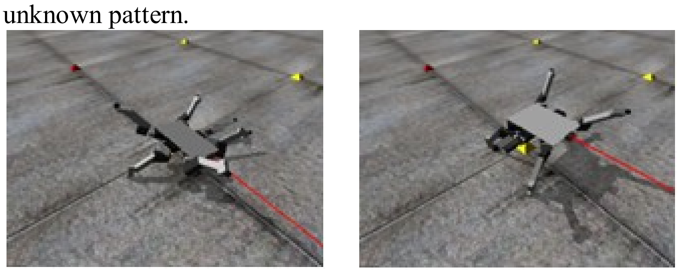

Fig. 4 Initial figures

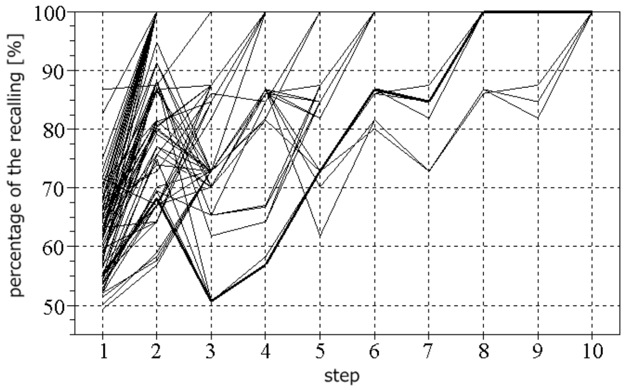

Fig. 5 Recalling the memorized pattern from known patterns

4.2 Multiple gait motion

An obstacle is set in the field. We investigate that the robot can select the motion, corresponding to the obstacles. The initial position and direction are (0,0) and minus direction. The size of the obstacle and the position of the center is 0.95 x 0.22 m and (-1.1, 0.2). The result is shown in Fig. 6. The trajectory of the robot is black line and gray box means the obstacle. Cross symbol shows the position that turning gait motion is selected. The robot moves to straight, during it does not recognize the obstacle. Facing the obstacle, it selects the turning gait motion.

As a consequence, it is clear that the robot is able to autonomously switch to gait motion by existence of an obstacle. This result is called as "basic motion", in order to compare to the other cases.

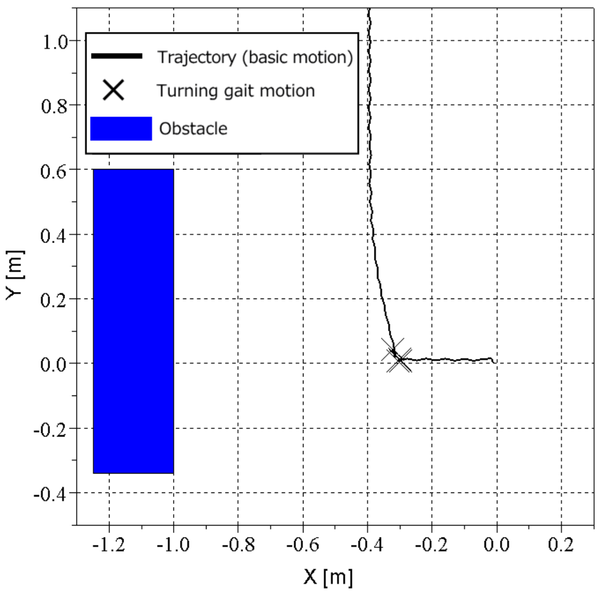

Fig. 6 Trajectory of the robot (basic motion)

4.3 Error of the touch sensor

In the real robot, errors of touch sensor that is set at each leg often occur. The robot that implements the Associatron can walk though the cases occur.

First, the values of some touch sensors are reversed at every step. Fig. 7 shows the trajectories of the robot, in the case that the number of the reversed value of the sensor is changed. When the number of it increases, the movement of the robot is more different from basic motion.

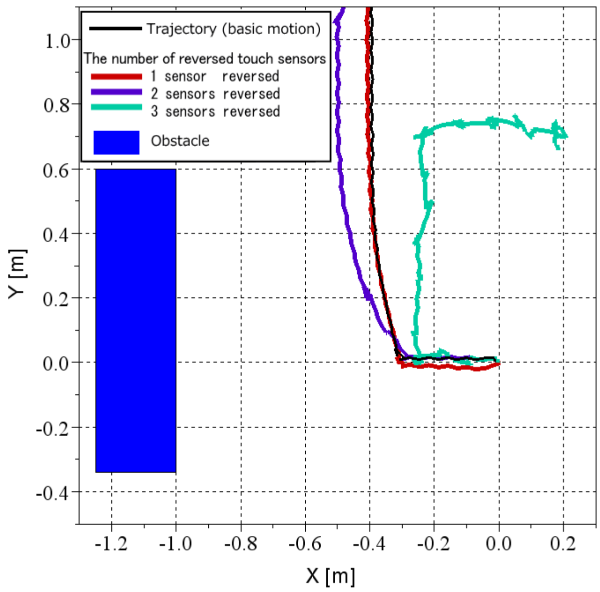

Fig. 7 Influence of reversing some touch sensors

Secondly, the interval that the error occurs is changed (every, 2, 3, 5, 10, and 20 step, respectively). The number of it is two in all simulations. When the interval is longer, the trajectory is more similar to basic motion.

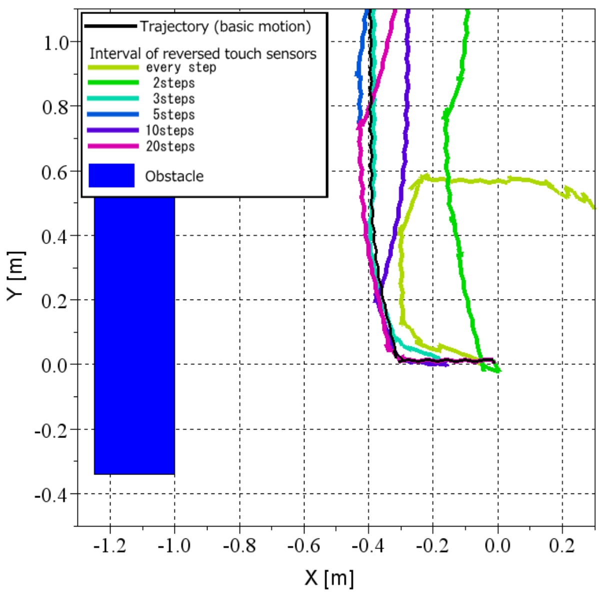

Fig. 8 Influence of the interval

5 EXPERIMENT

We investigate the validity of the algorithm by an experiment.

5.1 Structure of the experiment

In the system of the experiment, the Arduino Mega is adopted in order to control the robot (controlling of RC servo motor, and sensing touch sensor and PSD). Calculation of the Associatron is executed by the PC. The connection with the Arduino and PC is used by XBee that is a radio communication unit.

5.2 Experiment using a real robot

The experiment is performed at same setting of the simulation of basic motion. The snapshots are illustrated in Fig. 9. The trajectories are shown Fig. 10. Red line is experimental result. It is clear that the trajectory is similar to trajectory of the simulation of the basic motion. As a result, we confirm that the Associatron can be implemented with a real robot.

Fig. 9 Snapshots of the robot during the walking

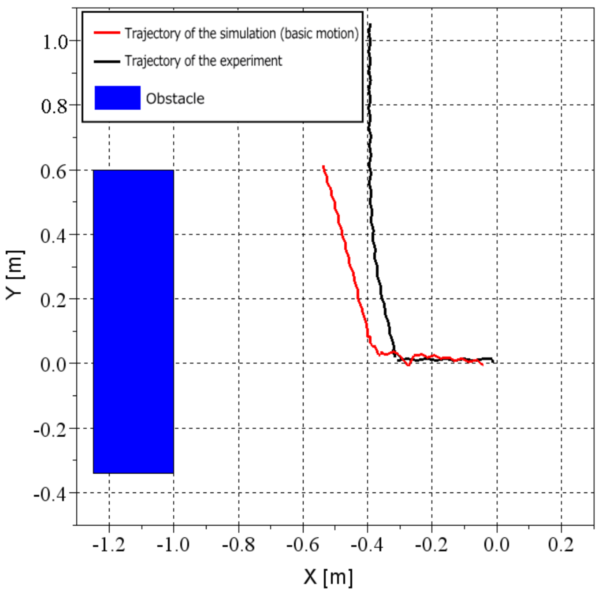

Fig. 10 Trajectories of a simulation and an experiment

6 CONCLUSION

In this paper, we proposed gait algorithm of a six legged robot using the Associatron. Simulations and an experiment of the obstacle avoidance were performed. As a result, the robot was able to select suitable gait motion, automatically. We confirmed that the algorithm was effective to gait motion.

In the future work, we will have the robot learn the motion automatically.

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