Aerial-Biped: a new physical expression by the biped robot using a quadrotor

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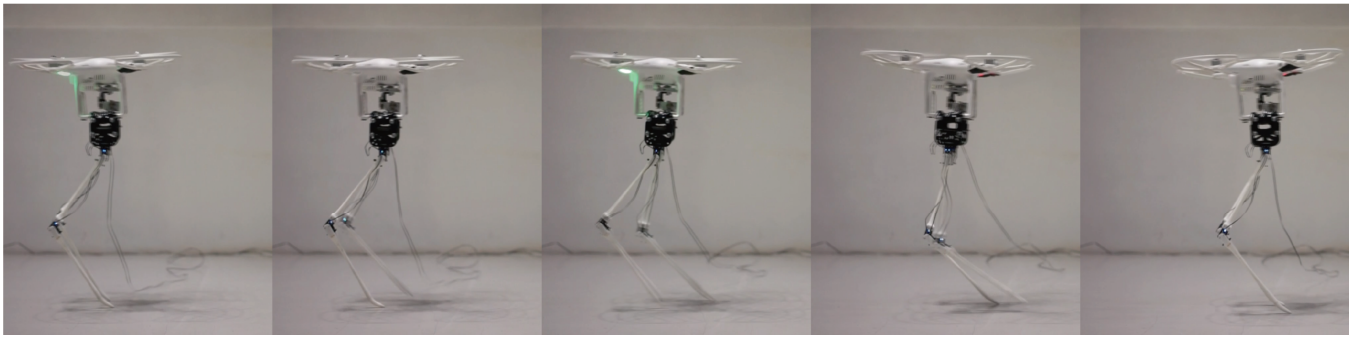

Figure 1: Aerial-Biped generating a gait in real time.

ABSTRACT

We present a biped robot which can move agiler than conventional robots. Our robot can generate bipedal walking motion automatically using the proposed method. By using a quadrotor for balance and movement it is possible to make an agiler movement, and generate a gait interactively and in real time according to the motion of the quadrotor using the optimized control policy of the legs. Our system takes the velocity of the quadrotor as an input and legs motions are produced so that the velocity of the foot in contact with the ground to zero, and bipedal walking motion is generated. The control policy is optimized using reinforcement learning with a physics engine.

CCS CONCEPTS

• **Computer systems organization → Robotics**;

KEYWORDS

robotics, entertainment, biped robot, unmanned aerial vehicle, gait generation

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1 INTRODUCTION

There has been a desire to make robot creatures like living things since ancient times. Progress in modern robot technology is remarkable, but there are still many difficulties and problems in order to realize a robot that has flexible thinking and can deal with the various environment, such as appears in science fiction movies.

We focused on a bipedal walking robot which is one of such difficulty. Bipedal robots currently have various problems, such as heavy motion, costs, and risk of falling. Realising a bipedal robot like a living thing is one of the biggest challenges so far and many studies have been conducted. We developed a biped robot for entertainment which can move agiler than ever before. We used the legs of the robot in order to realize the appearance features seen in bipedal walking, and we used a quadrotor as a means of movement. As a close approach, there is a biped walking robot using the buoyancy of a balloon[Ghassemi and Hong 2016]. Our robot uses quadrotor to enhance maneuverability, enabling a richer physical expression. In addition, motions of the legs are automatically generated according to the motion of the quadrotor using the proposed method As methods for realizing the appearance of walking motion of a robot for entertainment, there are using link structures[Coros et al. 2013; Thomaszewski et al. 2014]. In these methods, although an arbitrary motion trajectory can be installed in a robot, it is limited to a cyclic and static motion. We propose the method that allows the biped robot to move more dynamic and generate a gait interactively in real time.

2 METHOD

we focused on the velocity of the foot in contact with the ground. Our method is designed considering that the appearance of gait can be realized by generating the motion of the legs that makes the velocity of the foot in contact with the ground to zero. The

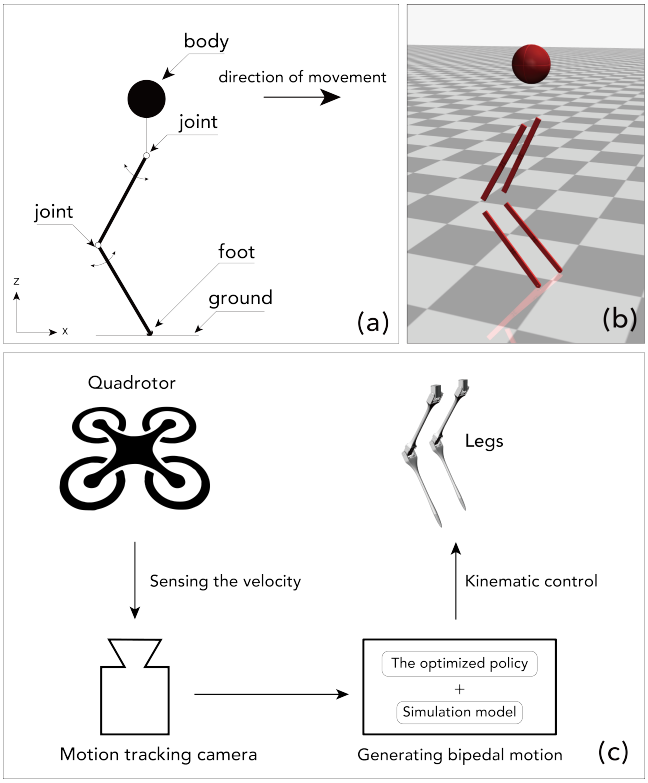

Figure 2: (a) (b) The robot model used to learn the control policy of the legs. (c) The control system in the real robot

control policy used for a gait generation is optimized by reinforcement learning with a physics engine. We define the robot model as shown in Fig. 2 and learning the policy is executed under following conditions.

(1) the body has one degree of translation freedom.
(2) each leg has two degrees of rotation freedom.
(3) the velocity of the body changes randomly.
(4) the robot gets a better reward as the velocity of the foot in contact with the ground is closer to zero

This our method can generate the robot foot trajectory automatically that realize the appearance of bipedal walking according to the body movement.

In the real robot, the velocity of the quadrotor is estimated by the motion capture data, and the input of the servomotors of each joint is generated using the optimized control policy. Several methods have been developed can interactively generate gaits of bipedal walking characters in computer animation[Holden et al. 2017; Peng et al. 2017]. Our method can generate a gait of the biped robot in the real world.

3 USER EXPERIENCE

At SIGGRAPH 2018 Emerging Technology exhibition, we will demonstrate the proposed gait generation system (Figure 3) and the real robot implemented using this system, Aerial-Biped. Attendees can see how the robot work and experience the robot foot trajectory

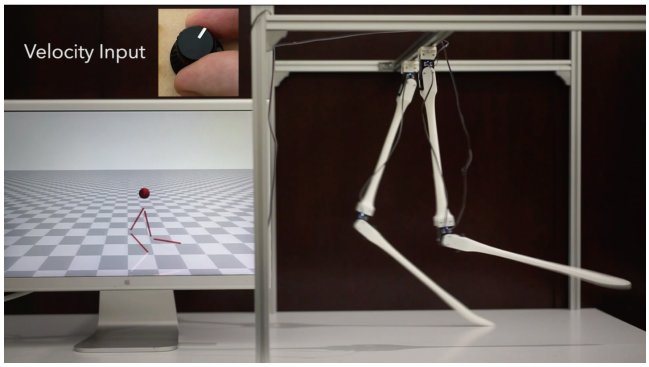

Figure 3: The robot foot trajectory generation system in the hardware

generation system by controlling the input interactively. In addition, they can control the quadrotor with the remote, and make the biped robot walk and experience choreography of the robot.

4 CONCLUSIONS AND FUTURE WORK

We propose a biped robot for entertainment using a quadrotor. This robot can move agiler than conventional robots and generate a gait in real time using the control policy which makes the velocity of the foot in contact with the ground to zero, as the velocity of the quadrotor is input.

In this study, assuming movement of the quadrotor, that is, movement of the body of the robot is 1 dimensional, the gait is generated. As the next plan, we are going to increase the degree of freedom of the body and legs. There is a possibility that various motions can be generated by this and it will become possible to imitate the motion of the character in the animation.

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