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Research Proposal

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Abstract. Earlier, There has been efforts to stabilize robots movement. Our main interest in robocup soccer domain is to develop these efforts and design a robust and reliable controller for humanoids in dynamic and uncontrolled environments.

1 Introduction

There are problems that don't allow robots to be useful for real-world problems, without help from human. Autonomous robots lack the ability to recognize and adapt to their damaged parts, stand up after falling, and detecting instabilities caused by external disturbance. Humanoid robots are unstable because their center of mass is high and when the robot is in single-support phase of walking small external impacts can cause instability in robot movement and if the robot doesn't react it will fall. Falling robot can cause damage to itself and other objects in their environment. So detecting instabilities and rescue behaviors are essential for robots in less controlled environment[1].

But it's not always possible to avoid robot to fall. Reflexive behavior can avoid damage to critical parts of the robot, and robot can stand up faster if it has a better posture. If the robot fell down and some parts get damaged it should continue it's operation. Animals sustain the ability to operate after injuries by creating qualitatively different compensatory behaviors[2].

Although Spark simulator doesn't simulate damages caused by impacts, it's necessary in real world application, specially where the robot is out of reach to be replaced or repaired. A reliable standing up method can also improve biped locomotion[7].

Our goal is to design a controller for humanoid robots with a defensive and reliable design. Because evolutionary computation requires evaluation of many potential solutions it is not possible to use real robots. With the recent advent of computer software known as physical simulation, it has become possible to simulate, instead of actually build, embodied robots which will reduce the cost and time required to use evolutionary methods[12].

2 Reliable Robots

Reliability is one of the most important problems that avoid using humanoids in real-world problems. There has been a lot of effort to make robots more flexible and adaptable in dynamic environments. In order to operate reliable there are several steps.

Robots must avoid falling as much as possible because it has bad effects on robot and the objects around it. Humans use reflexes after detecting instability. A common used criterion to detect instability is based on ZMP[4]. But humans violate this criterion while walking[3]. There is also a method based on pattern recognition. After instability is detected reflexes can be emergency stopping[5] or decreasing speed[1].

But sometimes when robot is not in a good position a small external force can cause the robot to fall. So, It is important to minimize damage in situations where a fall is unavoidable[6].Another step to increase reliability is ability to stand up after falling. Recognizing a fall is not difficult. But getting back on fits is not straightforward. Robot needs to use hands and knees as additional support points. Robot can recover by two static motions, for prone and supine positions[7].

The remainder of this paper is organized as follows: The next section describes different approaches used to design a robot to survive falling. In Section 2.2, we describe methods used to stand up, it's difficulties and robots which are able to stand up after falling.

2.1 Instability Detection, Fall Avoidance and Damage Minimization

Most commercial robots available today (like ASIMO[9] and QRIO[8]) use Zero Moment Point (ZMP) for gait stabilization and instability detection. Baltes et al. used gyroscope sensors in humanoids, to sense instability and stabilize walking gaits[10]. There is also an approach that uses translational and rotational velocity and information from robot sensors as input for pattern recognition. The pattern recognition classifies current state into different stability and instability classes and was trained on a simulator[11].

We will use this method of classification to detect instabilities, and initiate a stabilizing reex depending on the type of detected instability. Also SPARK simulator does not simulate damages, it is important for real-world robot to protect its important parts. So, when the instability is detected as an unavoidable fall reflexive behavior can be initiated for two reasons. To minimize the damage of falling and to be in a better position so that robot can stand up faster. Humans, for example, use reflex behaviors to fall in prone position because it's harder to get up from a supine position and it's more dangerous.

2.2 Standing up

Only few humanoid robots can operate after a fall. Advanced robots like Asimo have not been demonstrated to be able to get back into an upright posture.

Most of recovery methods use a static movement to stand up. Standing up from a supine posture requires strong arms, wide ranges of motion in key joints. But humanoids can stand up from a supine posture like humans. Humans usually stand up from this posture by rolling to prone posture. Standing from prone posture is relatively easier as it is possible to use knees as extra support points. Fig. 1 shows four steps required to stand up by a simulated version of Jupp robot[7].

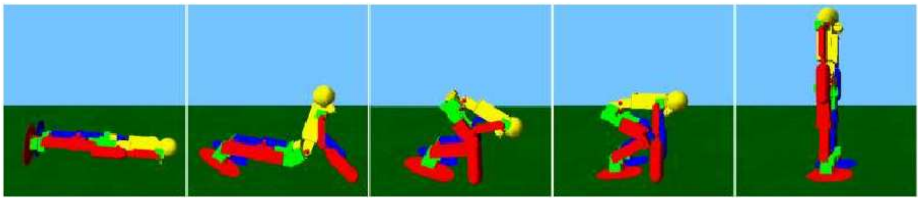

Fig. 1. Standing up from a prone posture.

Standing up can be spilt to these steps as shown in Fig. 1:

- Lifting the truck and bringing hands under the shoulders so they can be used as support points.
- Bending in the spine, the hip pitch and the knee joints to move center of mass projection on ground as close as possible to feet.
- Straightening the arms to let the robot tip over the leading edges of the feet.
- Bringing the body into an standing posture.

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