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Realtime human motion imitation by humanoid robot with balance constraint

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Abstract

Humanoid robots are made as mirror to the humans. Consequently, the humanoid motion is also expected to be real as human and it is natural to use human motion as an input to generate humanoid motion. This process is called motion imitation and there are several challenges posed due to kinematics and dynamics of the robot over the past decades. Although the work on the kinematic challenges is actively improving and notably better than dynamics, it allows the robot only to move and imitate slow actions. For the fast paced motions, *momentum* gets build up and needs dynamics to be taken into account. Due to the differences in redundancy between humanoid robots and humans, real-time imitation in humanoid robots while keeping balance and support changes is still an unsolved problem that need to be addressed.

During this research, imitation based on dynamics with task optimisation will be implemented on humanoid robot *NAO*, from Aldebaran Robotics. The imitation will be carried out online using marker-based motion capture system from *Xsens*, specifically *Xsens MVN* system.

Initially the captured motion will be preprocessed for its representation in operational space and then will be scaled to the robot's dimensions. From this scaled motion, the desired poses are taken and joint spaces in *NAO* and human actor will be mapped using the scaling function directly. The scaling constraints and the joint angle limits are taken into account for this process. Body Segment Parameter(BSP) Estimation is carried out on the scaled frames and the approximated *mass and Centre of Mass (CoM)* are calculated based on the principles of Modified Hanavan Model. The balance equations and the CoM trajectory are taken as the optimisation problem for the motion imitation. Finally the work will be presented as non-differential optimisation problem considering dynamics equations of motion and will be validated real-time on the humanoid robot.

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Notations

CoM	Centre of Mass

Abbreviations

CoM	Centre of Mass
ZMP	Zero Moment Point

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Introduction

Chapter 1

State of the art

1.1 First topic

1.2 Second topic

Chapter 2

Actual work

When dealing with rectangled triangles (see Figure **??**) I sometimes used this theorem from [1]:

$$a^2 + b^2 = c^2 \tag{2.1}$$

The demonstration is in Appendix A.

Chapter 3

Experiments

When trying to draw a rectangled triangle, my program comes up with Figure **??** that is neither rectangled nor a triangle.

Unless there is a bug in my program, which is unlikely, this research indicates that the whole theory on triangles having 3 sides has been wrong for years, maybe decades.

Conclusion

Appendix A

Proof of theorem 2.1

Proof. (2.1) was already demonstrated in [2]. □

Bibliography

[1] O. S. Pythagoras, "Theorem," *Some old journal*, vol. 1, no. 1, Feb. -580.

[2] O. A. Euclides, "Elements," *Self-published*, vol. 1, no. 1, Feb. -300.