Humanoid Robotics: Freedom of Movement

The importance of humanoid range of motion when designing robots to accomplish human tasks

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Introduction

- Through our research into humanoid robotics we seek to show how range of motion is a determining factor in defining what actions a robot can perform.
- This research is intended to be applied in the design of robots meant to perform human tasks, such as search and rescue, hazardous defusal, or autonomous exploration.
- To gather this information we modify a robot with only one axis of movement in its legs such that by the end of our research it has three, much like the range of motion of a human.

A Visual representation of our initial range of motion, as seen from the right:

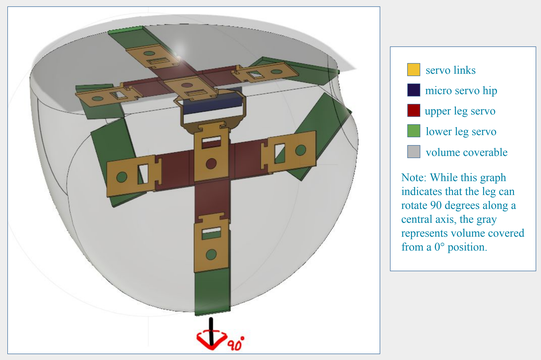
Background

- We were first inspired to begin our research as part of a larger project, meant to observe the interactions between autonomous humanoid robots in the pursuit of designing units meant to provide aid in disaster situations where human intervention would be hazardous or impossible.
- We study these small, inexpensive robots as a model for developing methods and designs that can be applied to larger, sturdier robots.
- If successful, these robots would save many lives and would prevent accidents like the Fukushima Daiichi nuclear disaster of 2011 from putting the health and safety of rescue workers at risk.

Process

- For our research experiment we modify the design of an EZ-Robot JD Humanoid bot (*Figure 1*).
- Our first prototype involves simply adding a perpendicular servo to the length of each leg (*Figure 2*).
- This proves to be too clunky, as the forward lift of each leg is far too low.
- We replace this prototype with a detachable hip mechanism (*Figure 3*).
- This allows for more balance but still does not allow for any additional rotational movement (*Figure 4*).
- To aid this, we redesign the chassis, expanding its internal capacity. (*Figure 5*).
- Our new design allows for the addition of two extra servos servos that add rotational movement to each leg. (*Figure 6*).
- We must now combine the new rotational axis with a mechanism that allows for a lifting axis.
- To accomplish this we design hip mounts for two additional servos (*Figure 7*).
- We combine our mounts with our updated chassis and assemble our final design (*Figure 8*).
- This bot now has a greater and fuller range of motion compared to its initial design.
- It is interesting to note that the proportions of our final design appear more "natural" than that of the initial design (*Figure 9*).

A visual representation of our final range of motion for the right leg:



Prototypes and Designs

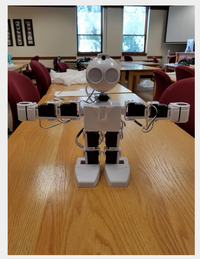


Figure 1: Initial Design

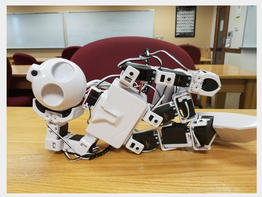


Figure 2: Hip Design Prototype 1

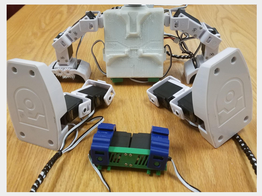


Figure 3: Hip Design Prototype 2

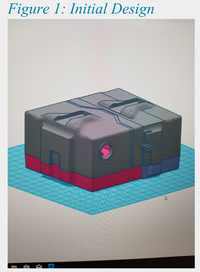


Figure 5: Re-designed Chassis

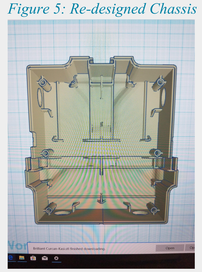


Figure 6: Cross-cut of Chassis

Figure 4: Application of HDSP2

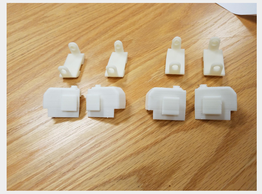


Figure 7: Hip Servo Mount Design

Figure 8: Final Design

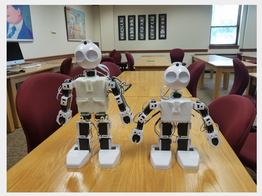


Figure 9: Proportion Comparison

Conclusion

- We find that with the addition of a single axis, lift at the hip, a robot is able to pose in more positions and perform actions far more fluidly than its single axis counterpart.
- Moreover, with the addition of the third axis, rotation at the hip, the additional actions appear more natural and are easier to balance.
- Therefore, we can conclude that if a robot's sole purpose is to perform acts with the aptitude of a human, it is exceedingly important that it is designed with a full range of motion in its limbs.

References

- Cluss, M., Laws, K., Martin, N., Nowicki, T. S., & Mira, A. (2006). The indirect measurement of biomechanical forces in the moving human body. American Journal of Physics, 74(2), 102-108.
- Dasgupta, A., & Nakamura, Y. (1999). Making feasible walking motion of humanoid robots from human motion capture data. In Robotics and Automation, 1999. Proceedings. 1999 IEEE International Conference on (Vol. 2, pp. 1044-1049). IEEE.

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- Thank you!