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Prof. Man

Self-Balancing Ball-Bot

A Refined Analysis

Brief Overview

My idea for a project is a self-balancing ball bot. This robot would operate under principles similar to that of the currently available Segway, except it would be unstable on an additional axis. That is, the robot would be susceptible to both pitch and roll, compared to only pitch. While it may seem like this would create an additional problem, the rewards, at least in my opinion, outweigh the risk. Control over an additional axis allows for greater control over the robot's movement. This would facilitate tighter turning and navigation of tighter spaces.

Stakeholders' Requirements

The User's Requirements

Due to the broad nature of applications for this robot, it is difficult to designate a particular "user." The robot could be used for anything from personal transportation, to a small-scale parcel delivery service.

If used for a small-scale delivery service, the most critical requirement from the user's perspective would be its efficiency in delivering packages. That is, the robot would need to quickly determine the most effective route to its destination and avoid any obstacles that may exist. If the robot is unable to navigate a relatively small environment in an expedient manner, the user would have to hand-deliver the package anyway. The main goal in this scenario would be to save people time. If the robot only adds another time-consuming task to an individual's schedule, there will be no market for it.

Additionally, the robot's package-handling abilities are of interest to the user. The user has to be confident that the robot will not drop, or otherwise harm its fragile payload. If using the robot for package delivery only adds additional risk, the market for this product will not exist.

If this robot is used for personal transportation, safety would be the principle concern. The robot must be capable of supporting a certain weight without causing stability issues. Also, the robot must be easy to operate. If the use of the product is a constant struggle for survival, the robot would not be acceptable.

The Client's Requirements

In the case of this robot, the client would be the supervisor or company overseeing production. In this case, the key requirements would be that the robot is profitable, easy to manufacture, and easy to support after sale. Because the objective of this robot is scalability and broad use, different versions and iterations would utilize common parts and assembly techniques. As a result, profits would be higher because less engineering time would be dedicated to making the robot adaptable to alternate uses.

Similarly, because each robot would have the same basic structure and operating principle, service personnel would only have to be trained on the underlying principles of operation, rather than being trained to support numerous different products.

The Designer's Requirements

For the designer, the key requirements would be that the robot uses readily available components, allows for ease of troubleshooting during prototype stages, and allows easy access to internal components.

Using components that are heavily sourced suggests that it should not be a problem to acquire more of those parts for prototyping, testing, or production. This is critical because an unavailability of parts designed into the robot would create the need for the designer to modify the design, and for service personnel to be re-trained in this new design. Additionally, if a component is readily sourced, there is a high probability that many vendors will sell the part, leading to lower, more competitive purchase prices.

Ease of troubleshooting and access to internal components go hand-in-hand. Both allow the product prototypes to be easily diagnosed, remedied and tested. If making a minor change to the internal configuration of the robot is cumbersome, the entire testing process is prolonged. Additionally, if a unit comes in for repair, it would be easier to troubleshoot and repair if the interior components were accessible.

Practicality

While the project is on the ambitious side, I believe it could be completed in a timely manner. Cost, however, may be the more prohibitive factor. Building just one electro-mechanical prototype may prove to be costly. Design compromises may be made in the interest of cost for prototyping, but the underlying concepts should hold true for scaled-up versions. This project could serve as more of a proof-of-concept.

One additional aspect of this product that requires further investigation is how the product should react in a fault state. That is, if the unit loses power, how can the designers ensure that it will remain upright and not cause its payload to fall?

Skills Necessary

Considerable skill in electrical hardware design, software design, and mechanical design would be required for completion of this project. While I do have experience in both the electrical and mechanical hardware design, additional knowledge and experience would be necessary. Additionally, someone with more advanced programming skills than my own would be needed in order to complete this project in a timely manner.

SWOT Analysis

Strengths

- This robot has greater maneuverability than what is currently available.
- Scalability of the robot means it can be adapted in size to accommodate the transport of larger payloads.

Weaknesses

- Adding an additional axis around which the robot is unstable means more complicated balancing.
- Fail-safes must be considered. That is, if the robot were to fail or lose power, we would need a way to ensure its payload isn't damaged.

Opportunities

- The scalability of this project means it can adapt to countless applications. Any application involving transport is a market opportunity.

Threats

- If consumers don't see this as a worthwhile improvement, the product won't gain a significant market value.
- If there isn't a way to ensure safety, this product will fail.