Viability of Commercial Depth Sensors for the REX Medical Exoskeleton

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by

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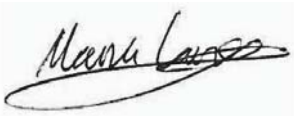
The author declares that this is his own work, except where due acknowledgement has been given. The thesis is submitted in fulfilment of the requirements of a Masters in Engineering at Massey University, New Zealand.



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Abstract

Closing the feedback loop of machine control has been a known method for gaining stability. Medical exoskeletons are no exception to this phenomenon. It is proposed that through machine vision, their stability control can be enhanced in a commercially viable manner. Using machines to enhance human's capabilities has been a concept tried since the 19th century, with a range of successful demonstrations since then such as the REX platform. In parallel, machine vision has progressed similarly, and while applications that could be considered to be synonymous have been researched, using computer vision for traversability analysis in medical exoskeletons still leaves a lot of questions unanswered. These works attempt to understand better this field, in particular, the commercial viability of machine vision system's ability to enhance medical exoskeletons. The key method to determine this will be through implementation. A system is designed that considers the constraints of working with a commercial product, demonstrating integration into an existing system without significant alterations. It shows using a stereo vision system to gather depth information from the surroundings and amalgamate these. The amalgamation process relies on tracking movement to provide accurate transforms between time-frames in the three-dimensional world. Visual odometry and ground plane detection is employed to achieve this, enabling the creation of digital elevation maps, to efficiently capture and present information about the surroundings. Further simplification of this information is accomplished by creating traversability maps; that directly relate the terrain to whether the REX device can safely navigate that location. Ultimately a link is formed between the REX device and these maps, and that enables user movement commands to be intercepted. Once intercepted, a binary decision is computed whether that movement will traverse safe terrain. If however the command is deemed unsafe (for example stepping backwards off a ledge), this will not be permitted, hence increasing patient safety. Results suggest that this end-to-end demonstration is capable of improving patient safety; however, plenty of future work and considerations are discussed. The underlying data quality provided by the stereo sensor is questioned, and the limitations of macro vs. micro applicability to the REX are identified. That is; the works presented are capable of working on a macro level, but in their current state lack the finer detail to improve patient safety when operating a REX medical exoskeleton considerably.

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