Leveraging Configuration Spaces and Navigation Functions for Redirected Walking

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Redirected Walking Limitations

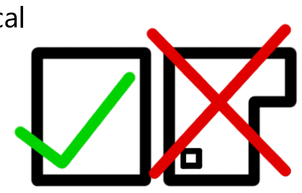
Redirected walking allows for natural locomotion in VR which has been shown to increase a user's presence and their ability to navigate [5][6]. However, it still has several limitations including a general requirement for ideal physical environments and a lack of development for multi-user experiences. For part of my dissertation topic I am designing an algorithm with the goal of alleviating both of these limitations.

Non-ideal Physical Environments

Assumptions are usually made regarding the physical environment:

- Rectangular space
- Free of any obstacles
- Boundaries and other elements are static

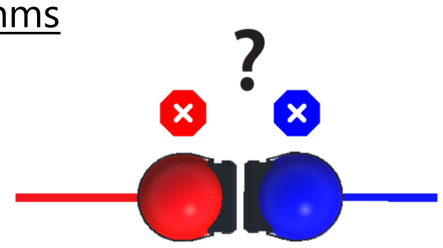
When these assumptions are met we call the physical environment ideal.



Multi-user Algorithms

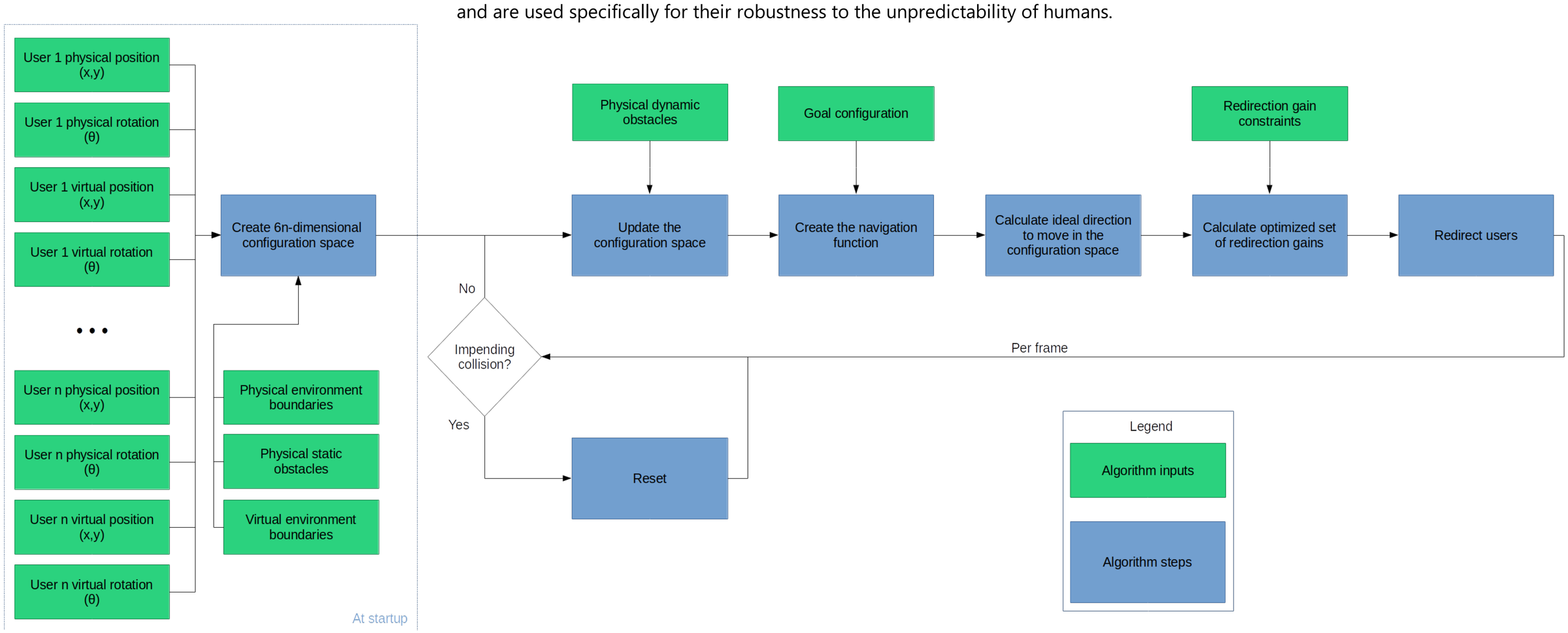
Current redirected walking algorithms were designed for single user experiences. Some research has been done on using existing single user algorithms in a multi-user experience [1][2]. However, by designing algorithms for multi-user experiences instead of attempting to use existing single user algorithms we can integrate several desirable features such as:

- Proactive user-user collision avoidance
- User mapping convergence



Continuous Optimized COnfiguration Alignment (COCOA)

The conceptual design for COCOA uses configuration spaces [3] and navigations functions [4], techniques from the field of robotics, resulting in a computationally effecient algorithm that removes the need for ideal physical environments while allowing multi-user experiences. Configuration spaces are higher dimensional spaces where each dimension represents a degree of freedom of the system and each point (called a configuration) maps to a unique value. Navigation functions are restricted potential functions on the configuration space that allow for gradient descent based navigation schemes and are used specifically for their robustness to the unpredictability of humans.



Future Work

Once completed COCOA will become the foundation for my dissertation. To build upon it I will use COCOA to attempt to solve some interesting problems that cannot be solved with current redirected walking algorithms. Some possible research vectors that can use COCOA are:

- Effectiveness of COCOA versus general (reactive) RDW algorithms
- Effectiveness of COCOA versus planned (predictive) RDW algorithms
- RDW effects on collaboration
- Space requirements for n-user redirected walking
- Dynamic obstacle avoidance
- The handshake problem (user mapping convergence)
- Mobile robot based haptic feedback

References

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[6] M. Usoh, K. Arthur, M. C. Whitton, R. Bastos, A. Steed, M. Slater, and F. P. Brooks Jr. Walking > walking-in-place > flying, in virtual environments. In *Proceedings of the 26th annual ACM SIGGRAPH*, pages 359-364. ACM, 1999.

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