

論文 / 著書情報
Article / Book Information

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Title(English)	Spatiotemporal Gait Guidance Using Audiovisual Cueing with a Synchronized Walking Avatar in Augmented Reality
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
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(博士課程)
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論文要旨

THESIS SUMMARY

系・コース： Department of Graduate major in	情報工学 知能情報	系 コース	申請学位 (専攻分野)： Academic Degree Requested	博士 Doctor of	(学術)
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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

This thesis is titled “Spatiotemporal Gait Guidance Using Audiovisual Cueing with a Synchronized Walking Avatar in Augmented Reality”. The purpose is to present and evaluate a walking avatar augmented reality (AR) system on gait guidance of the elderly. The system was developed to address the gait challenges often faced by the elderly population and the limitations of current gait guidance systems. This thesis is split into 4 chapters that highlight the motivation, development, evaluation and conclusions of the research.

The first chapter, Introduction, introduces the motivation of this research. Gait impairments reduce quality of life. As people age, they experience some level of gait impairment. Due to the complexity of gait, spatiotemporal gait guidance has been shown to be difficult. Few studies have been able to guide gait both spatially and temporally, as they largely focus on single-modality cues which often cannot independently adjust related gait parameters without unintended side effects. The remaining problem is that gait is a spatial and temporal process and both modalities should be guided simultaneously. This study hypothesized that combining spatial and temporal cues using a synchronized avatar could enable independent guidance of gait parameters, leading to more effective gait guidance. The purpose of this thesis is to develop and evaluate the use of an AR-based system designed to deliver synchronized spatial and temporal gait guidance via a synchronized walking avatar.

Chapter two highlights the development of an AR-based synchronized avatar gait guidance system and its evaluation using healthy young participants. The system was developed to provide simultaneous spatial and temporal cues and evaluated on young participants. The system ran on a head mounted display (HMD) and presented a virtual avatar synchronized to the foot contact timings of the user and audio cues synchronized to the avatar's step timings. The system featured 4 modules: foot contact detection, human phase estimation, gait phase synchronization and avatar and cue presentation. Spatial cues were provided through changes in the avatar's distance from the user, while temporal cues were provided simultaneously via phase difference adjustments in avatar footstep timing. The experiment was conducted with 8 healthy young participants and tasked them with walking while observing the avatar. The results show that distance changes led to similar increases/decreases to the participant stride length. Cycle time changes were a result of changes in phase difference. The results highlight that, though simultaneous, the cues could target gait parameters almost independently based on modality.

In Chapter 3, the phase estimation module of the previous system was improved to provide real time phase estimation, and the new system was evaluated through experiments with 19 elderly participants. The study aimed to observe both the immediate and carry-over effects of spatial and temporal cueing on elderly gait. Four experimental conditions were tested: distance increase, distance decrease, phase increase, and phase decrease. The distance changes had significant proportional changes to stride length while the phase changes had effects on the cycle time. The immediate effects on stride length and cycle time were consistent with those observed in the first study with younger participants. However, the elderly participants showed additional carry-over effects in certain conditions, particularly when the distance was increased or phase difference decreased both of which increase gait performance and stability, reducing fall risk, highlighting its potential for gait rehabilitation.

In Chapter 4, General Discussion, the effects and mechanisms of the developed system were explored. The results of the two studies highlighted the effectiveness of the AR avatar system and combination of cues. Visual cues have been shown to be effective in spatial guidance and auditory cues have a dominance in temporal guidance. The use of AR allowed for a multi-modal approach to be taken and that cues could be provided simultaneously. The potential mechanisms at the core of these results are found in the use of the mirror neuron system and central pattern generator (CPG) theory. The spatial cues effectiveness relied on the mirror neuron system, where observing an action (such as walking) would illicit similar neuron activity as performing the same action. By observing the apparent changes in stride length of the avatar through the changes in distance allowed participants to subconsciously adjust their stride lengths to match the change. Temporal guidance was achieved through the synchronization of the audio cues and avatar steps which activated the CPG, which is responsible for the rhythmical movement of the body. Using different mechanisms which are largely automatic/subconscious we were able to combine the cues and guide gait both spatially and temporally which was not achieved in other systems. The chapter finishes with a summary and future applications in rehabilitation and guidance studies.

In conclusion, this thesis shows that the synchronized walking avatar system with combined spatial and temporal cues in AR can effectively guide gait parameters, achieving both immediate and carry-over effects. The system is able to independently adjust gait spatially and temporally. Potential applications include gait rehabilitation, and general gait training programs.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1 copy of 800 Words (English).

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