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Title(English)	Tether Control of Leader Following Robot to Support Home Oxygen Therapy Patients
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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

専攻： Department of	機械宇宙システム　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　(Engineering)
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This thesis aimed to investigate tether control in a mobile robot designed to support Home Oxygen Therapy patients.

Chapter 1 gives the background of the research. Chronic Obstructive Pulmonary Disease (COPD) is a common respiratory condition where airflow through the lungs is restricted, with patients experiencing coughing, wheezing, and shortness of breath. Home Oxygen Therapy (H.O.T.) is a medical treatment frequently prescribed for COPD in which the patients are supplied concentrated oxygen from an oxygen tank or concentrator. An assistive robot can improve the quality of life of H.O.T. patients by carrying the H.O.T. equipment, thus reducing their physical burden and increasing their freedom of movement. Since Home Oxygen Therapy requires the use of a cannula to supply oxygen, the system is inherently tethered and this represents a good opportunity to use a tethered robot follower. A survey of existing academic research and commercial systems showed that a suitable solution did not exist, and consequently there is a need for a robust robot system which can follow the user while also being simple to operate and low-cost. To meet these requirements, this research considers a differentially steered mobile robot with a tether interface, which is evaluated by Home Oxygen Therapy patients as much as possible.

In Chapter 2, three leader following control methods are presented with theory and simulated trajectories: *Pseudo-Joystick*, *Follow the Leader*, and *Follow the Leader with Constant Distance*. *Normal path deviation* was also introduced as a metric to compare the accuracy of leader following. An investigation into the effects of control parameters found that Pseudo-Joystick control was negatively affected by longer tether lengths, while Follow the Leader was unaffected.

Chapter 3 describes experiments with human leaders and a hardware prototype. Motion capture experiments were used to measure and compare the performance of *Pseudo-Joystick* control and *Follow the Leader with Constant Distance* control under controlled conditions with healthy users. Following on from these, the robot's performance with real Home Oxygen Therapy patients was evaluated; the results of a leader following experiment and a questionnaire survey are presented and analysed. From the practical experiments it was shown that the *Follow the Leader with Constant Distance* algorithm was capable of following the user more accurately than *Pseudo-Joystick*, but both algorithms gave reasonable following performance. The questionnaire survey of Home Oxygen Therapy users identified that overall they found *Follow the Leader with Constant Distance* to be better and found *Pseudo-Joystick* control to be more uncomfortable.

Chapter 4 introduces several additional follower modes designed to improve follower performance in certain situations or address issues with previous control methods. Side following and front following modes were developed to allow the robot to remain in the user's field of vision while following their trajectory. Simulation and motion capture results were presented for two types of side following control: *Side Joystick* mode and *Side Tracking* mode; the latter was shown to have improved performance. Experiments with *Front joystick* mode showed that it could be operated in open spaces, but steering was relatively difficult for the user on more complex courses. Brake mode was introduced to improve the safety and usability of the robot, especially in busy environments. The problem of tether snagging was also briefly investigated, showing how a tracked trajectory is distorted if the tether hits an obstacle.

Chapter 5 describes leader following experiments conducted with a Home Oxygen Therapy patient in an outdoor environment. Two participants, one healthy user and one Home Oxygen Therapy user, were asked to walk various routes around their local area (mainly around a park and the nearby train station), while using an assistive device to carry their oxygen tank. Three different devices were compared: a conventional oxygen cart (unpowered); a commercially available cart with powered wheels; and a robot follower. The user's heart rate and oxygen saturation (SpO2) were measured, and these values were then used to compare the effect of each device on the user. The number of participants in this experiment was too few to draw statistically robust conclusions about the robot's performance (a minimum of eight participants is typically required for this). However, the results of the experiment implied that the robot performed comparably to the conventional cart, and sometimes better. This represents an interesting preliminary result which can be used to justify further experiments with a larger number of Home Oxygen Therapy patients in future.

Chapter 6 introduces an airport carrier robot as a further application for the leader following control discussed in previous chapters, demonstrating the generality of the research. The implementation of the control is described along with the results of testing in an outdoor environment.

Chapter 7 summarizes the contribution of the work in this thesis, gives final remarks and ideas about possible future work. In particular, this chapter highlights the work required to progress this area of research from its current state to a finished commercial product ready for use by Home Oxygen Therapy patients. Additional feedback and impressions from working with Home Oxygen Therapy patients are also discussed.