論文の内容の要旨

Design and Control of Personal Mobility with Spherical Wheels Composed of Serial Kinematic Chain
（直列リンク系で構成される球状車輪をもつパーソナルモビリティの設計と制御）

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The sphere can be rolled to omni-direction on the ground because of the symmetry characteristic of a sphere. It can generate rolling velocity on the ground including inclined plane at any position and at instant time. Until now, most of spherical wheels are installing an unactuated sphere wheel and actuated rollers to drive a sphere wheel. Namely, a sphere wheel can be rolled by static friction between active rollers and a passive sphere wheel. Therefore, the slip is likely to occur between a sphere wheel and active rollers. At this time, it is difficult to transmit high torque to a sphere wheel.

This dissertation proposes a new driving mechanism of a spherical wheel with three actuated links jointed to the spherical wheel, serially. This mechanical structure is similar with a manipulator of serial link type when considering a sphere wheel as a manipulator's end effector. Therefore, it is easy to transmit high torque to a spherical wheel in comparison with a friction driving mechanism using active rollers. This dissertation suggests three kinds of omni- directional mobilities (**SO(3), SO(2)** and **SO(1)**) installing link-driven spherical wheels or a wheel as forms of a personal mobility.

SO(**3**) installs three spherical wheels for a use of a hospital bed and a personal mobile platform. The three contact points with respect to the ground make the supporting region of triangle shape. And, **SO**(**3**) has a static stability and can generate large driving torque to

transport person or load with three link-driven spherical wheels. In the experiment, **SO(3)** shows omni-directional movement and high load transportation ability.

SO(**2**) needs a controller to balance an attitude by itself because it has only two spherical wheels and does not have static stability like a bicycle on the ground. LQR(Linear Quadratic Regulator) controller based on the simplified dynamics of wheeled inverted pendulum is utilized to stabilize the attitude of **SO(2)**. The designed controller realizes omni-directional movement of **SO(2)** and maintaining its balance with a rider.

A spherical wheel of **SO**(**1**) does not have a kinematic constraint by wheel placement with respect to the ground. Therefore, **SO**(**1**) falls down without controlling to maintain its attitude by itself because it does not have static supporting area like a car, train and **SO(3)**. **SO**(**1**) can be simplified as a wheeled inverted pendulum model in sagital and longitudinal planes, respectively. In the experiment, **SO**(**1**) stands up and stabilizes at a balance attitude with LQR controller by itself. However, it is difficult to avoid joint limitation and singularity of link-driven spherical wheel to move omni-direction due to the strong nonlinearity and mechanical structure of **SO**(**1**). For that reason, this dissertation introduces to design nonlinear controller in real-time based on simplified nonlinear dynamics of **SO**(**1**). The designed nonlinear controller stabilizes an attitude of **SO(1)** and the spherical wheel shows that it can generate high driving force for a person to rider on **SO(1)**. The mobility and its maneuverability are investigated by experiments to discuss its performance and easiness for human rider, intuitively.