Crawler Mechanism with Circular Section to Realize a Sideling Motion

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Abstract—

In this paper, a novel crawler mechanism for a sideling motion is presented. The crawler mechanism has a circular section and has active rolling axes at the center of the circles. Conventional crawler mechanism can convey heavy weigh, however they can not move to side. And previous crawler unit sinks into the soft ground when it whole body is inclined during moving. The proposed design solves this drawback by means of a circular section. An actual prototype model has been developed to illustrate the concept and to perform preliminary motion experiments, through which the basic performance of the Crawler Vehicle with this proposed Omni-Crawler mechanism was confirmed. An prototype has been developed to illustrate the concept. Motion experiments, with a test vehicle are also presented.

Keywords: Crawler, Sideling Motion, Circular Section, Mechanical Design, Pipe Inspection

I. Introduction

Previous crawler can not move to a side way. Therefore it is difficult for previous crawler to avoid the obstacle and immediately as shown in Fig. 1(a). In addition, when previous crawler move on the soft ground, the edge of the crawler unit is apt to sink as shown in Fig. 1(b). In this paper, the crawler mechanism to realize a sideling motion and .

Application for Pipe inspection robot.

B. Weak point of conventional crawler which realize the sideways mobility

In order to realize holonomic omni-directional motion, there exist some many commercial wheels with based on small passive rotational wheels. However, these mechanisms do not have a high level of ability for step climbing or gap traversal (for example the chasm of the door of an elevator) in environments, such as houses, offices and hospitals. This limitation stems form the fact that the diameter of the passive wheels is much smaller than the diameter of the whole wheel mechanism. This is particularly apparent when the mobile

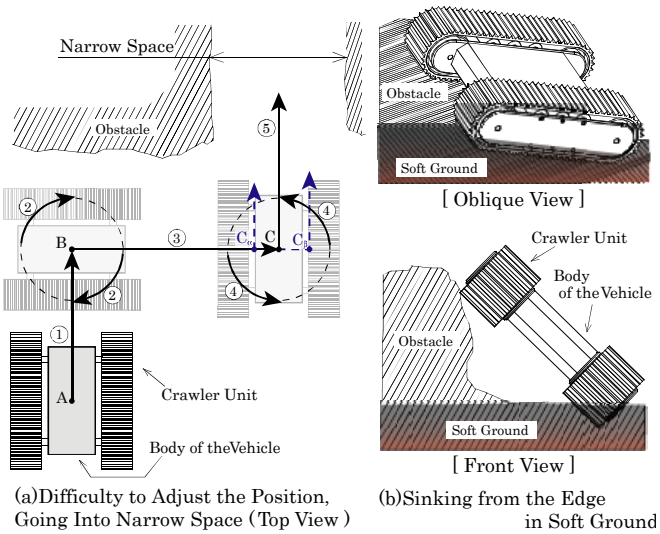

Fig. 1: Problems of Conventional Crawler Mechanism

II. Basic Concept of the Crawler with Circular Section

The basic concept of the Crawler with circular section is shown in Fig. ,

The crawler has the circular section. And this crawler module has the active rotational axis. Therefore, the sideway motion can be realized by this configuration.

In addition above feature, this configuration has another point as shown in Fig. 3.

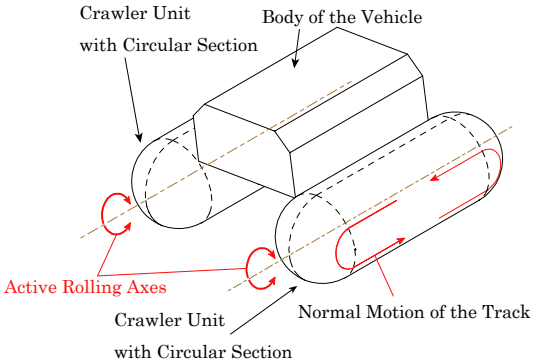

Fig. 2: Basic Concept of Omni-Crawler with Circular Section

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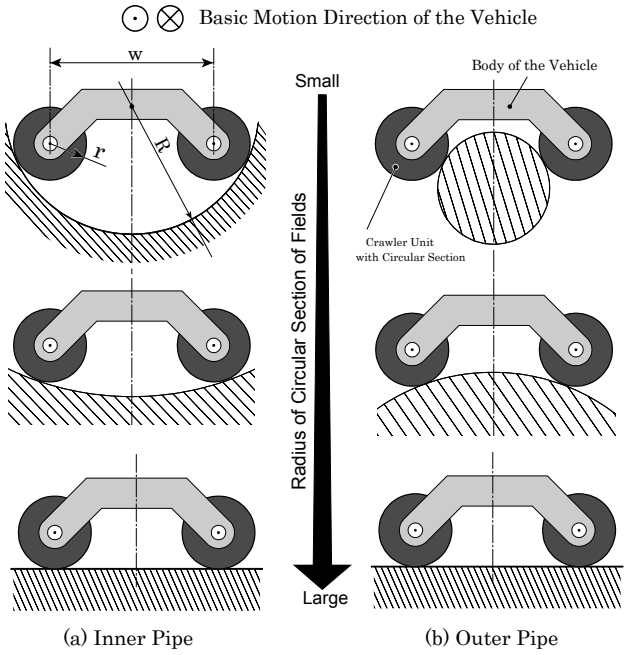

Fig. 3 Auto-Adjustable Function to the Curved Field like Pipe without any special degrees of freedom

When previous crawlers move inside of pipes or outer surface of pipes, the edge of the crawler belt are contacted at points. On the other hand, when the crawler with circle section moves inside or outer surface of pipes, the crawler unit practically contacts the surface with some areas, because of the deformation of the surface of the circular crawler belt, the touching area of the crawler unit should be changed with some area not the line.

In addition, as mentioned in the introduction as the problem of the previous vehicle, the depth of sink of the crawler unit can be reduced.

To move pipes to the vertical direction, with more than 3 units, the vehicle can move toward to the top inside vertical pipes.

If the vehicle has the joint mechanism between the former crawler module and rear one, the vehicle can climb much high steps like the Packbots[] doing.

robots mounting these mechanisms move in the direction perpendicular to the passive wheel axis as shown in Fig. 2. The step that the mobile robots can overcome is significantly low if compared to the size of the whole wheel because of the small diameter of the passive wheels.

In this paper, we propose a new wheel mechanism with high step climbing capability for omnidirectional mobile robots, and show the mechanical design of that wheel in detail.

III. Mechanism of the Crawler with Circular Section

In this section basic configuration of the crawler mechanism with circular section is described. At first, the mechanism of the Omni-Ball[] authors developed before, being based on the crawler mechanism is explained.

A. Basic Configuration of "Omni-Ball"

A driving mechanism that facilitates motion in an omnidirectional way is feasible by using a spherical ball[9]. However, this mechanism has many mechanical parts such as rollers and guides, etc. One of the key developments presented in this paper is a new mechanism for AGV to realize that omni-directional motion with symmetric property.

The basic section structure of "Omni-Ball" is shown in Fig.4[10] and a 3D-concept model is shown in Fig.5. In Fig. 5 two hemispheres rotate passively, and in the center of the Omni-Ball lays the active rotational axis. In order to rotation, both the passive hemispheres. Note that each passive rotational axis is independent, so that each rotation of hemispheric wheel is also independent.

When the active axis rotates, the Omni-Ball produces a propelling force in a perpendicular direction to the active rotational axis, as shown in Fig.4. On the other hand, this wheel does not produce a propelling force in the horizontal direction in Fig.4(right one), so that this mechanism can similarly move in an arbitrary direction by combining through the combination of at least three propelling forces. As a more practical model, a motor for a wheel type is being designed. By placing the motor inside the wheel itself, the whole structure of the Omni-Ball becomes more compact.

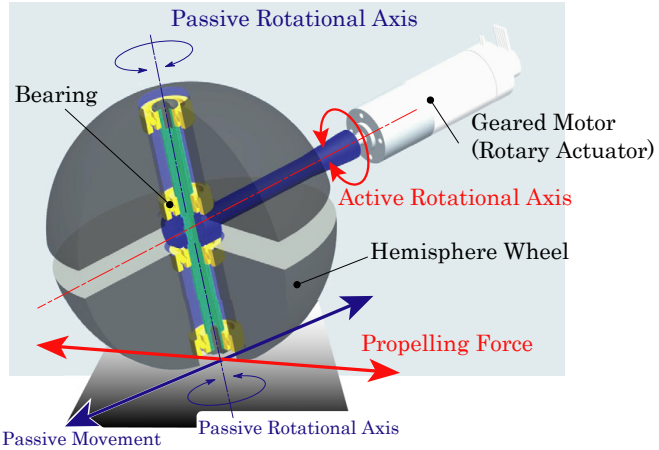

Fig.4: Basic Structure of the "Omni-Ball"

B. Basic Configuration of "Omni-Crawler"

The comparison between the principle of the Omni-Ball and that of the Omni-Crawler is shown in Fig. .

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As stated in the previous section, the hemispherical wheel of the Omni-Ball is rotated passively in Fig. , on the other hand, the Omni-Crawler can produce propelling force not only the side-way but also forward-back way. If the rotary actuator mount on the hemispherical wheel of the Omni-Ball, the velocity in the forward-back way must be changed depends on the angle of the axis of the hemispherical wheel to the ground, because the relative radius of the should be change based on the inclining angle of the wheel mechanism. On the other hand, as shown in Fig. 5(b), the Omni-Crawler the crawler mechanism to realize a sideling motion, the velocity to the crawler to forward direction does not change based on the inclining angle of the driving unit as shown in Fig. 5[b-1] and [b-2].

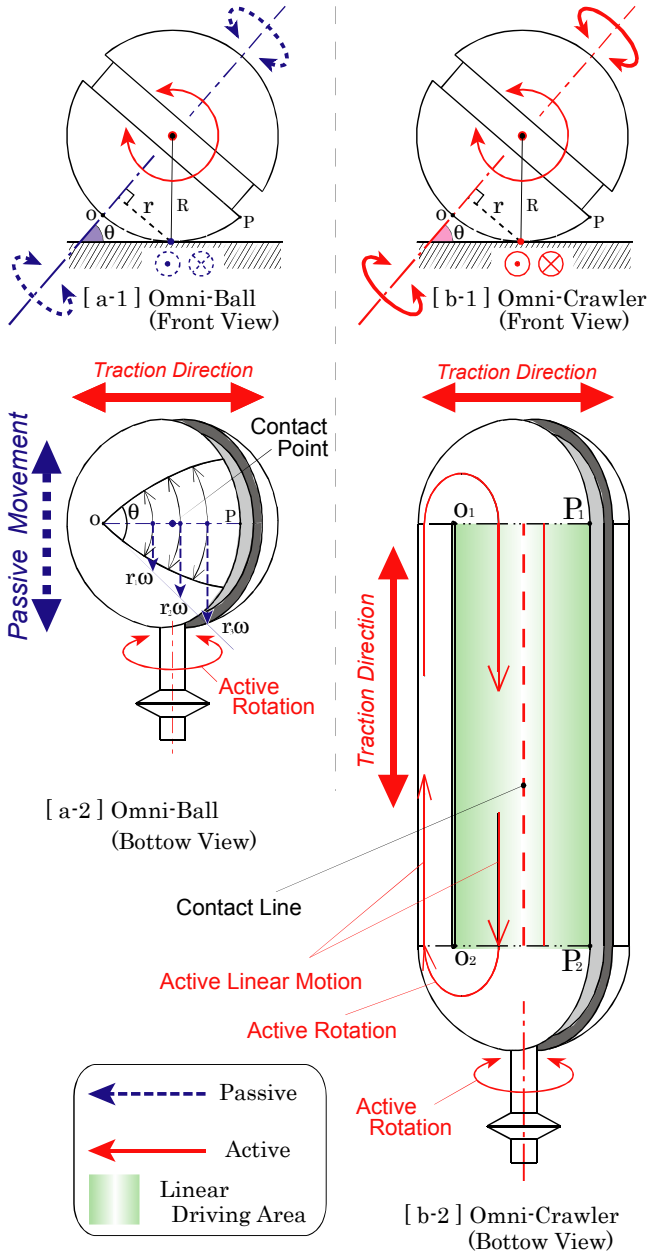


Fig.5: Basic Principle of the "Omni-Crawler"

C. Actual Prototype Model of "Omni-Crawler"

(c-1) Inner Mechanism of the Crawler

The inner mechanism of the crawler is shown in Fig. 6. The geared motor rotates the inner shaft and bevel gear set change its rotational direction to the vertical direction to the shaft of the motor and sprocket is rotated at the end. The end of the front and rear of the inner mechanism unit, there are the shaft for the sideling motion of the crawler. By rotating these shaft in rolling axis actively, the sideway motion can be realized. Tensioner for the belt is mounted at the reaer part.

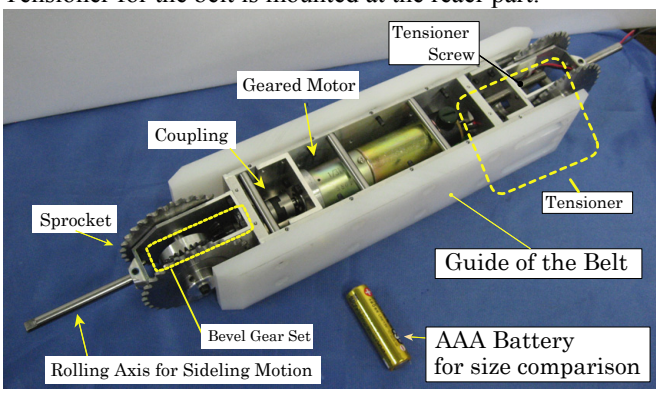


Fig.6: Mechanism inside the Crawler Unit

(c-2) Crawler Belt with Circular Lug

In order to realize smooth sideling motion, the shape of the section of the crawler should be circle. The lug of the crawler is shown in Fig.

The Surface of the Lug module, the rubber is set to the lug supporter. The material of the lug supporter is SUS304; metal.

The overview of the belt of the crawler is shown in Fig.8.

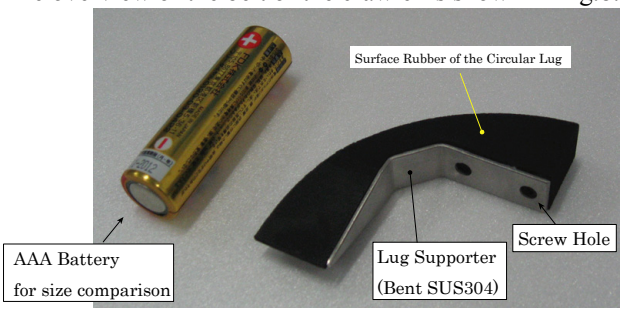


Fig.7: Lug of the Crawler Belt

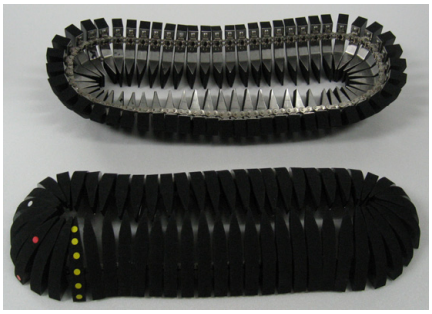
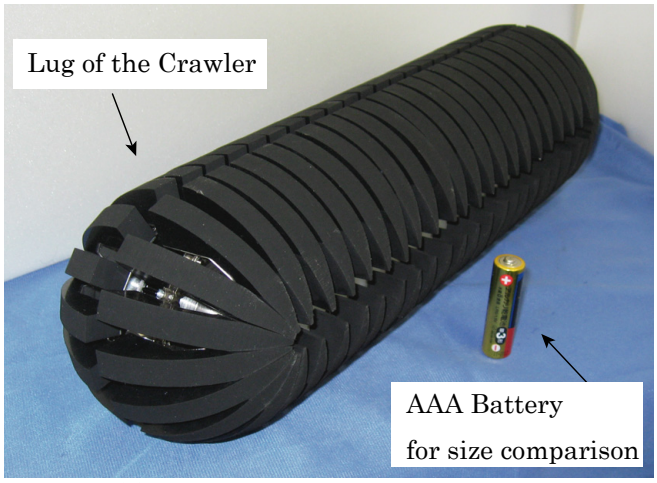
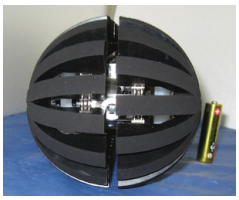


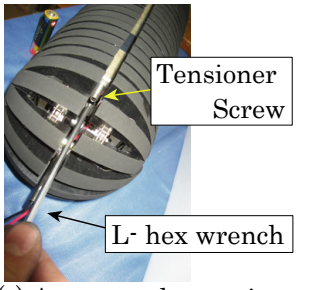
Fig.8: Belt of the Crawler (top one is reverse side of the crawler)



(a) Oblique View the Crawler Unit



(b) Front View



(c) Access to the tensioner

Fig.9: Actual Prototype Model of "Omni-Crawler" Unit

Table.1 Specification of One "Omni-Crawler"

Length	359 mm
Distance between two sprocket axes	255 mm
Width	104 mm
Height	104 mm
Diameter of the section circule	104 mm
Weight	3.05 kg
Material of the lug surface	Nitrile Rubber
Material of the lug supporter	SUS304
Pitch of the lug	12.7 mm
Motor	90W (NIPPO MM-26E) x2

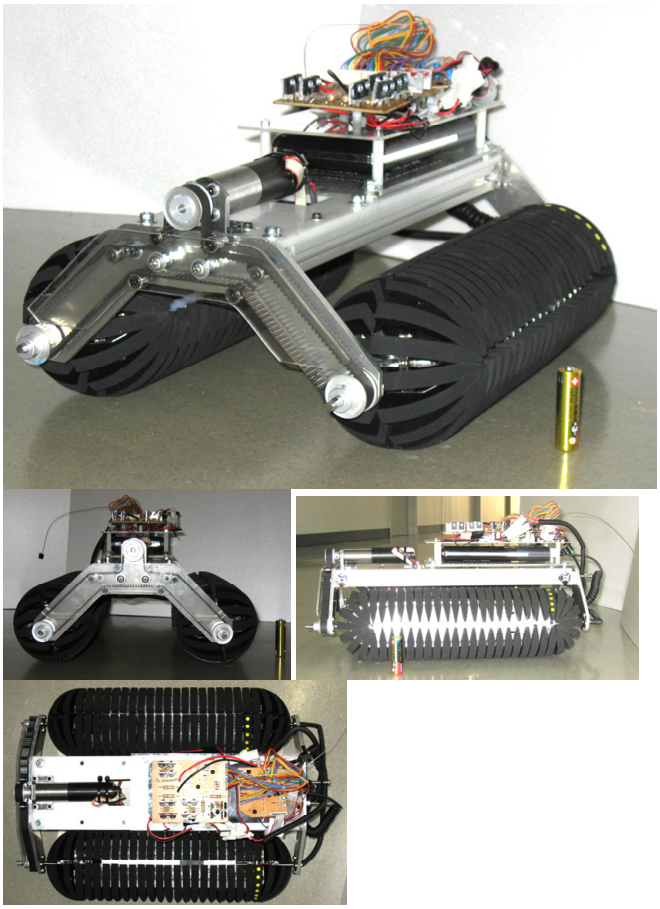


Fig.10: Whole View of the Crawler Vehicle

Table.2 Specification of the Vehicle

Length	420 mm
Width	314 mm
Height	190 mm
Weight	8.59 kg
Distance between two crawler rolling axes	210 mm
Motor for a sideling motion	Faulhaber 26W
Battery	14V

IV. Configuration of the Crawler Vehicle

The configuration of the vehicle is shown in Fig. 10 and specification of the vehicle is shown in tab.2.

There is the motor to rotate both axes of rolling shaft from the right and left crawler units for realizing sideling motion. The battery and electronic circuit boards are mounted on top of the body.

. Experiments of the Crawler Vehicle

In this section, we describe a set of experiments conducted to confirm the performance of an actual prototype model of this crawler vehicle with omni-crawler

A. Omnidirectional Motion

As one of the basic performances of this robot, the omnidirectional motion should be confirmed. One example of such motions is shown in Fig.11. It was observed that this prototype model has the ability to move in an arbitrary direction smoothly. Please see the movie attached on this paper.

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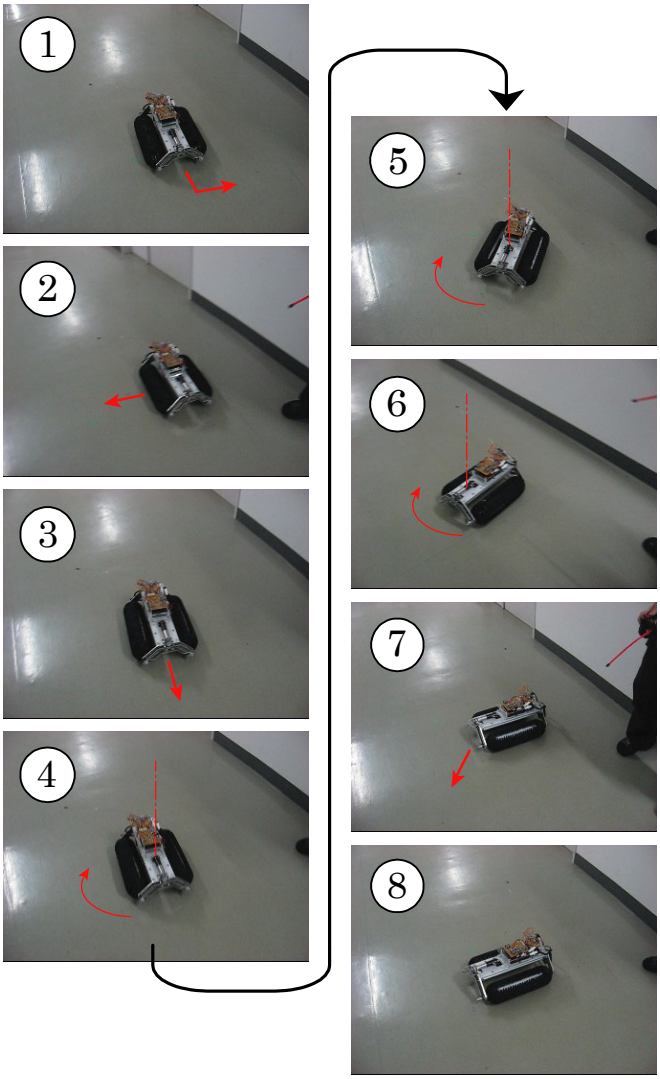

Fig.11: Omnidirectional Motion on Floor

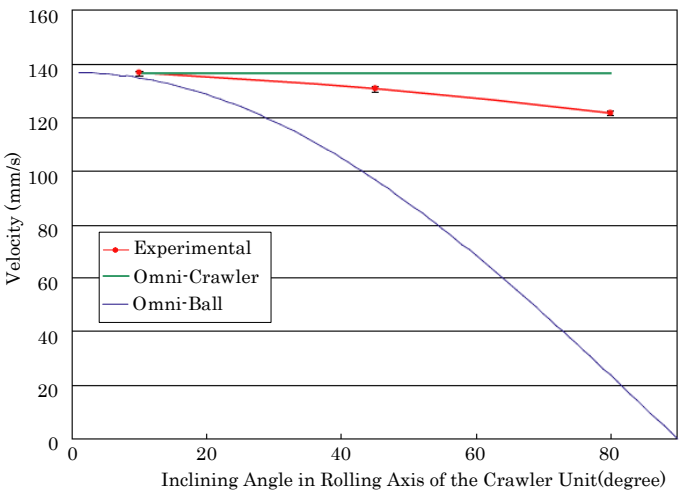

Fig.12: Comparison of the Speeds in the forward direction

The graph shows that the speed to the forward direction of the crawler is the almost the same speed. That speed does not to depends on the inclining axis of the crawler unit very much. Just only the It seems that the reason why the velocity of the as explained in Chapter3 with Fig.5.

B. Step Climbing and Gap Traversing Motion

The function of climbing steps and traversing gaps were also confirmed. It was observed that this prototype with Omni-Crawler can climb the step and traverse gaps not only forward direction but also in sideway direction.

C. Moving on Pipe.

Moving on pipe motion was also confirmed

It was observed that this prototype with Omni-Crawler can move not only small but also large pipe without any adjustment.

(a) Small Diameter **(b) Large Diameter**

Fig. 13: Moving on Pipes (small and large one)

IV. Conclusion

In this paper, we showed a new crawler mechanism with circular section realizing sideling motion, “Omni-Ball”, and an omnidirectional vehicle with this wheel mechanism. We confirmed the basic characteristics of the crawler mechanism and the motions of the crawler vehicle through some experiments.

In future works, the optimization of the mechanism of the crawler and the materials of the circular lug and suspension mechanism for the vehicle will be done and tested.

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