Production of a space elevator climber

Team “Aoki Bravo B”

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We designed and manufactured a climber to compete Berutoteza for a space elevator competition in Europe. Improved reference to the body that was created last year. Here are the results of the test process.

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1. Introduction

The team "Aoki Bravo B" is made up with Nihon University students. Originally, The team was made for the belt tether climbers competition compete in Japan.

While receiving advice from many of the friends of the control system laboratory, leading to completion. The production has a lot of people involved.

Features of the climber, it is small and lightweight. So it is easy to mount on a tether.

2. The development-process of your Climber

2.1. Concept

Roller mechanism of a prototype made up of the various elements, to decrease slipping of rollers used to feed a variety of mechanisms, such as industrial machinery, production of the climbers made it to apply the mechanism.

The climber race we participated in last year was held in Japan. We use twin motors. The motor was loaded too much because of non-synchronization between the two motors. Therefore the climber could not reach the goal. To solve those problems we made the design and manufacture based on the following concepts in order to overcome the disadvantages of climbers within a year. We began with the drive mechanism.

- Efficient driving mechanism
- Smooth to the detachable tether
- Emphasis on stability rather than speed
- Replace worn rollers allow
- Consider the balance of approximately

Based on these concepts, we designed and made the belt tether climber.

during the design of the drive mechanism (belt tether in this case) had to be the same across the work. Therefore, mechanisms are needed that can be spread freely between the rollers.

In order to design a roller mechanism, at first, we made some models from the LEGO. And then we decided to use the parallel link mechanism (Fig. 1).

![Fig.1 LEGO models](image)

Not only changing roller distance by using this mechanism, thought to be able to easily mount to Belt tether. We actually made a link using the parallel link mechanism (Fig.2).

![Fig.2 parallel link mechanism](image)

When we lift the climber it was actually able to do an attachment to the Belt tether so easily for this mechanism. Also, you can now easily adjust the pressing force of the roller by
this mechanism. Adjust the spring force that pushes through the parallel linkage arms (Fig.3).

![Fig.3 Adjust the spring force](image)

The following description of the roller. Roller uses a urethane rubber burned into the aluminum ones. Urethane is a very strong rubber, has been used, for example roller coaster.

We use a reliable motor making by MAXON 90W-DC motor. We control a climber Speed to change the rotational speed by using the H8 microcomputer. The genuine motor amplifier is very expensive so we use the other motor amplifier to control “sumo” robots. And then we succeed cost-cutting Here are details on the battery and motor in Table1.

![Fig.4 NC milling machines](image)

### Table1 Details on other component

<table>
<thead>
<tr>
<th>Component</th>
<th>Manufacture</th>
<th>Specification</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor</td>
<td>MAXON</td>
<td>RE35</td>
<td>1</td>
</tr>
<tr>
<td>Motor AMP</td>
<td>vs tone</td>
<td>VS-WRC005</td>
<td>1</td>
</tr>
<tr>
<td>Battery</td>
<td>HYPERION</td>
<td>Li-Po Battery</td>
<td>1</td>
</tr>
<tr>
<td>Drive Roller</td>
<td>Hirama Gomu Kizai</td>
<td>Urethane:70 Aluminum:A5052 Diameter:60mm</td>
<td>1</td>
</tr>
<tr>
<td>Driven Roller</td>
<td>Hirama Gomu Kizai</td>
<td>Aluminum:A5052 Diameter:60mm</td>
<td>1</td>
</tr>
</tbody>
</table>

Because of reducing a driving friction, we use nylon rollers for guides. The guide uses nylon rollers. Reduce friction when driving in this way.

### 2.3. Manufacture

We use CAD design. This is to create a part using the NC milling machines from CAD data in the university. The main components of the roller mechanism is using a 5mm thick A5052. (Fig. 4)

### 2.4. Assembly, Integration & Testing

We assembled almost all parts by hand. We can assemble almost parts by using M4 with a diameter of 4mm.

The pressing force between the rollers of the climber is regulated by the spring. We can know the pressing force when the climber lifts.

However the pressing force is appropriate, big acceleration causes the slip between the rollers and tether. So we write a program to accelerate gradually in order to prevent the slip.

We use the roof of the school building (15m altitude) for the experiment we hung down the tether rope from the root for moving up and down.

Then the experiment succeeded. The climber started off to climb up a rope over 15m and gradually accelerated. After contacting the top of the bumper and started and dropping. It was slow but succeeded in elevating automatically (Fig.5).
2.5. **Project Management**

Our laboratory has been studying the theme of a space elevator, has produced two machines for rope climber and belts in it. However, climbers belt tournament held in Japan last year did not lifting. Conversely rope climber was relatively successful.

So this year anyone did not make the belt climber.

The climber began to produce for the belt I have a couple of reasons. First, because last year had been participating in the belt climber. Second, the situation of not many people is that I thought might be able to be made freely without dissension.

One situation was hard but I am more than expected. I was weak because the production of the circuit. Positions that will interfere with the graduate students are also available.

Now, however, I have been helped by other lab people who are familiar with automatic control.

3. **Conclusions**

The climber has some problems now.

One issue, there is a problem in point of control. The climber is made automatic control. But now, it can’t come back by itself when the climber get tether stuck. We need a program to drop to judge for themselves the climber.

We also need a sense of slip of the roller with a rotary encoder. Urethane rubber roller is used because it resists abrasion but if the climber continues slip. Feedback control precisely to detect slip must be needed to prevent slippage of the rollers of the roller wear.

4. **Reference**

1) Goichi Ben Toru Fujii Hiroyuki Kawada Co
2) Hirosi Yokoi Koujiro Matushita Co