Development of the Portable Equatorial Mount with high operability and applicability

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I'm developing a portable equatorial mount that has high operability and applicability. An equatorial mount is a device that rotates observation tools such as a telescope and a camera according to the diurnal motion of the celestial body to enable more detailed observation. A highly accurate tracking function has been realized through the first and second machines.
After that, I started the third machine development aiming to differentiate it from the commercially available equatorial mount. In equatorial mounts, the axis of rotation must first be aligned with the celestial north pole, but since the this accuracy has a large effect on tracking performance, I aim to automate axis alignment. Further, as a weak point of the portable equatorial mount, when the direction of the telescope is changed to taget another celestial body, the entire mount may be slipped off, and in that case, it is necessary to re-align the axis again. In order to solve this problem, the declination rotation can be controlled by a motor. Next, with the aim of messuring the accuracy, in addition to the existing index, periodic motion, a unique index for directly obtaining the tracking speed is being able to be mesured. The final goal is to publish the assembly guide on the Internet.

First, in order to realize special rotations of ultra-low speed and high torque in fine steps (smoothly), I used a stepping motor, subdivided voltage changes, and a worm gear with a high reduction ratio. As a result, I achieved a high torque of approximately 56kgf * cm even in the declination rotating part, lightest Unit in the third machine, and the step angle was in increments of 0.00018 °.
Next, regarding the operation of the motor, I decided to link with a smartphone. By using the Arduino-compatible ESP32 microcomputer for the program processing, I succeeded in communicating with an Android smartphone via Bluetooth and changing the motor speed with low cost. On the other hand, it has not been confirmed yet on iOS smartphones, so I am considering switching to WiFi communication.
Also, if the shaft of the gear does not mesh correctly, the accuracy will be greatly affected. Therefore, I devised a method of fixing the shaft. Instead of tightening the motor with screws to fix it, the motor is sandwiched with screws so that fine adjustments can be made even after fixing. In addition, the bearing uses commercially available L-shaped metal fittings, and this can also be finely adjusted and fixed to achieve a certain degree of accuracy.

With the first and second equatorial mounts, I was able to confirm a certain degree of tracking accuracy, but I could not show an objective value. For that reason, I'm writing a program that uses Python to determine the angle of view and declination of the observation target.

Presently, in version 3 machine, only declination rotating unit is assembled. However, there are still unsoleved issues. Being heavier by devised method of fixing and ext. make the lower units require more torque, and brought about necessity to re-design these units considering it. Moreover, the Python program for messuring the tracking accuracy is not completed yet, and it is required to adjust thresholds more.

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