

Fig. 1. (Top) Design of DORIS with the decoupled user workspace. The end effector (handle) can be moved freely within the decoupling mechanism, which is disjointed from all the translation links, rotation links, and actuators. The inset figure represents a user manipulating the end effector of DORIS. (Bottom) Design of the decoupling mechanism. Four encoders at each corner are utilized for calculation of the position and angle of the end effector. When the brakes are engaged, the movement of the end effector is no longer allowed. Note that a handle is removed in the top figure to make the structure more clearly visible.

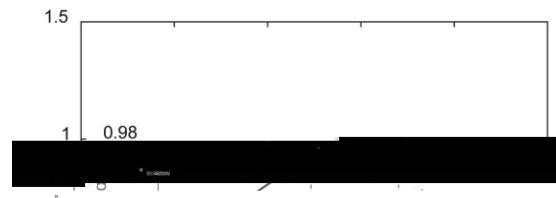
TABLE I
SPECIFICATIONS OF DORIS. ALL ARE MEASURED VALUES

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Fig. 3. Schematic of the five-bar linkage mechanism inside of the decoupling mechanism. The relative position ($\mathbf{r}_{EE/DM}$) and relative rotation angle ($\theta_{EE/DM}$) of the end effector (solid black square) referenced to the decoupling mechanism can be obtained by using four measured angles ($\alpha_1, \alpha_2, \alpha_3$, and

TABLE II

EASURED ASS



D. Development of a Platinar haptic robot with liquid ionized polymer base
The Platinar haptic robot was developed by using the same structure as the Platino haptic robot, except for the base. The base of the Platino haptic robot was made of a solid aluminum plate, whereas the base of the Platinar haptic robot was made of a liquid ionized polymer base. The liquid ionized polymer base was composed of a rectangular frame and a central base plate. The central base plate was made of a liquid ionized polymer, which was a mixture of a polymer and a liquid ion. The liquid ionized polymer base was designed to provide a stable and flexible base for the haptic robot.

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