A PHANTOM® device with 6DOF force feedback display and sensing capabilities

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Abstract. This paper describes a technical solution that has been devised to embed the SensAble PHANTOM® 6dof force feedback device with a light-weight 6dof force sensor from ATI: the Nano43. The design has been made in a way such that original performances are kept in terms of force feedback and sensing.

Keywords: 6dof force sensing/display device.

1 Introduction

At CNRS, in the frame of the ImmerSence project[1], we aim at achieving a demonstrator with various modeling of the interaction between two persons through an intermediary object (person-object-person, acronymed POP in the remaining). Examples where such an interaction applies, are collaborative transportation and assembly tasks, virtual prototyping, etc. Models will be built upon knowledge acquired from collaborative robotics, cognitive science as well as the use of haptic and multimodal patterns of communication. These models, integrated together will allow us to provide avatars with a set of realistic behaviors during the realization of POP tasks. The POP tasks demonstrated can be carried out with different configurations: either two persons manipulating an object in a shared virtual or mixed (i.e. augmented reality) environments or a person performing a collaborative task with a virtual avatar.

Preliminary investigations on this scenario (see companion paper in this proceedings [2]) using desktop haptic devices, such as the PHANTOM Omni®, revealed limitations in performing interactive POP tasks because of the lack of torque feedback. Moreover force and torque sensing will allow a better haptic patterns identification and interpretation. These supposed *haptic patterns* can ideally be used as bricks of an hypothetical *haptic language* which, in turn, can be used at a higher level control of virtual avatars interacting with users through direct touch (pure communicative aspects) or through a virtual object

[1] www.immersence.info

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manipulation (functional tasks aspects). Therefore, it appeared important to conceive a 6dof[2] haptic sensing/display device.

This paper presents a technical solution which allowed to mount a 6dof force sensors from ATI (the Nano43) on a SensAble PHANTOM 6dof force feedback device (High Force 1.5). The obtained system is an integrated 6dof force sensing/display device that is aimed for our research and development in haptic interaction in POP application scenarios.

In addition to the previous concern, there are other reasons and benefits gained by a force display embedded with force sensor:

- it is possible to have a direct measure of the resultant wrench acting on the device without noise and computations/approximations that are consequent to collecting these data from an identification algorithm which uses the motors' torques (in direct drive case) or current measures;
- force sensor can be used directly in admittance-type feedback (i.e. when forces are obtained from constrained-based methods, it is more robust and stable to know actual external forces applied by the user on the manipulated object (proxy), so that they are directly integrated in the computation of the dynamics);
- characterization of haptic texture rendering as presented in [1] where a force sensor from ATI (the Nano17 model) has been mounted on a 3dof force feedback from SensAble.

The remaining of the paper will describe the prototype we devised and that is made by SensAble Technologies to provide a solution that satisfies our requirements.

2 Technical Solution

At first we envisaged using the same mounting solution that has been proposed in [1]. However given our specific requirements we favored a solution where the force sensor is mounted between the handle and the remaining mechanical linkage of the force feedback display. The reason of this is to be as close as possible to the interaction point between the user and the force display. Nevertheless, because of the presence of an actuator within the handle which ensures torque feedback along the handle's axis; the armature of the handle's actuator (i.e. external cover) is attached to the handle where as its shaft is statically linked to the hammerhead and subsequently, to the remaining mechanical linkage of the PHANTOM 6dof. Therefore, it was not possible to use a small and plain force sensors such as the Nano17 ATI force sensor.

In addition, secondary but important constraints which guided the design, is to have a reasonable price solution, which means:

- using commercially available products,
- keep similar performances of the original products, and
- make as less as possible modifications/adaptations.

[2] Dof, states for Degrees Of Freedom.

Therefore, the adopted technical solution allowing to customize the PHANTOM 6dof with a 6dof sensing capability close to the hand is as follows:

- make use of an available PHANTOM Premium 1.5 High Force/6DOF device, although the solution would also apply to other PHANTOM 6dof devices;
- make use of an ATI Nano43 with DAQ F/T transducer: this force sensor model have a cylindrical whole which in fact allowed to bypass the difficulty to change the handle and the attachment mechanism;
- A modified handle to accommodate the ATI force sensor.

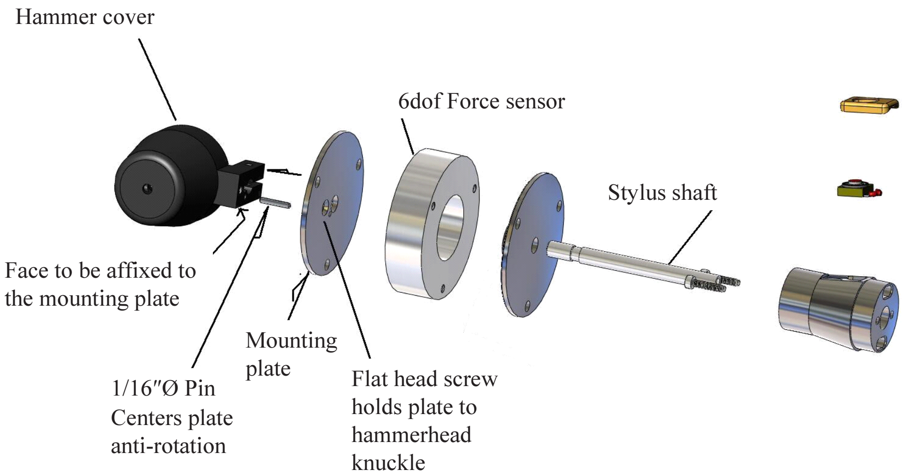

Fig. 1. Mechanical parts of the new SensAble 6dof stylus with force feedback integration

Note that the solution is in fact using two commercially available products; the problem remains only in the mechanical design of the handle (named also stylus) in order to accommodate the ATI sensor without changing a lot the original mechanical design. The sensor is mounted closer to the pivoting gimbals and thereby closer to the original end-point of the force feedback device (hammerhead). This provides more accurate measurement of the forces and torques exerted by the user. The position of the control switch button was moved to be behind the sensor so that the user can easily reach it during operation.

The resulting new handle is illustrated under different view in the figure 2. The overall new device is illustrated in the figure 3.

In this version the additional weight induced by the force sensor is negligible but could of course be compensated by a the mechanical balance counterweight used originally by the display. There is however an additional apparent inertia and its effect will be investigated in future work that make usage of this solution in our applications.

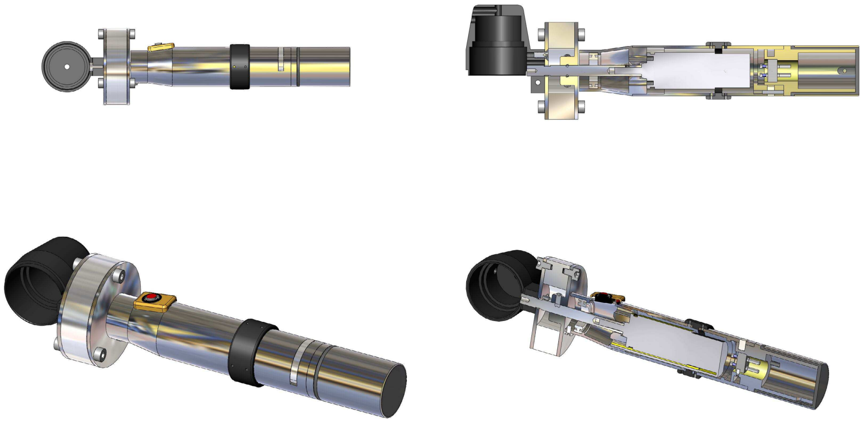

Fig. 2. Different views (left side and isometric) of the new PHANTOM 6dof handle with the 6dof Nano43 force sensor from ATI

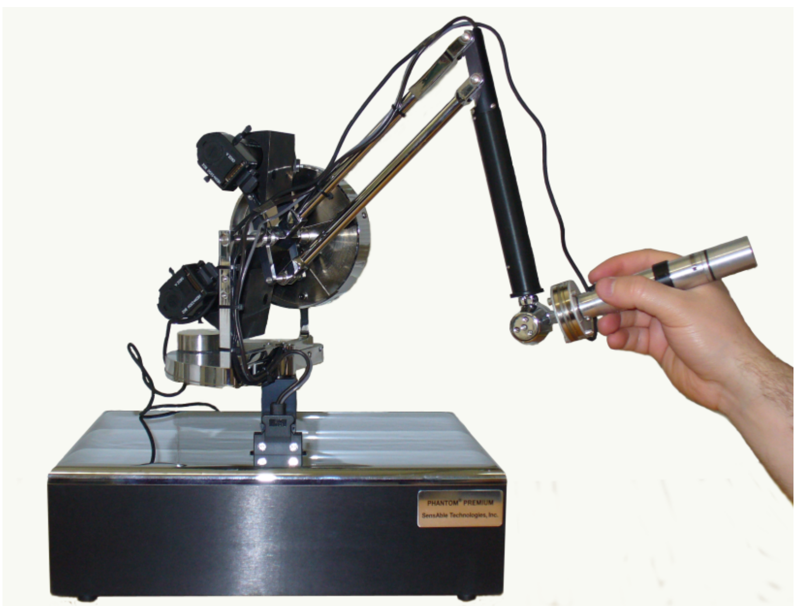

Fig. 3. A 6dof PHANTOM device with 6DOF sensing sensor from ATI (Nano43) and the new handle

3 Conclusion

This short paper presented a technical solution for the design of A PHANTOM device with 6dof force feedback display and sensing capabilities. The design allowed keeping the performances of both the PHANTOM device and the force sensor. It will be used in further investigations for research on desktop human/virtual avatars interaction.

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