Force feedback

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The term force feedback has a relatively long history in various fields, which led to various meanings that are sometimes unclear.

Teleoperation

The term force feedback originates in the field of teleoperation. It has been introduced at a time when it was important to denote the difference between single-direction tele-actuating systems and fully interacting active systems.

The most widely spread design for single-direction tele-actuating systems consists in a forward motion control of a slave, associated to a visual feedback. In order to complete such systems so as to obtain a full mechanical coupling, the most natural mean was adding a slave-to-master "force feedback" to the motion control. However, one must note that though this denomination, real implementations usually did not feature strictly a force feedback. In fact, early telemanipulators were mostly designed as differential servo-positioners (hence, as bidirectional motion control), instead of exhibiting truly a force feedback system [Goertz, 1953].

Also in the context of teleoperation, a slightly different meaning of force feedback (or effort feedback) referred to the transmission to the user of the effort sensed by the remote robot. This second meaning, consequently, does not refer to the category of data managed in the systems, but to the sensation finally felt by the user.

Both the meanings (complete coupling and sensation felt by the user) are often confused with each other's, though they actually differ. The ambivalence of the term originates in the definition of the force considered. Indeed, the term feedback implies that some signal is fed back. Since a signal is by essence directional, as soon as a signal (that, here, represents a force) is considered, one should precise its two extremities. In the term force feedback, what are the origin and destination? That remains unclear. Depending on the author, the paper, the situation, the considered origin may be a force sensor, the output of a computation, the force output by a force actuator, something else, or a vague mix of all of them. And, conversely, the considered destination can be either a force actuator input, a computation, the human being himself, etc.

Amplified Handles

A third usage of force feedback appeared later in the domain of amplified handles (motion followers, assisted command, etc.), when trying to improve such handles by inserting an active generator in it. Indeed, letting the handle become active (letting it generate for example vibrations, etc) proved to be of interest to overcome the softness of the lever, to re-enable the amplified handles with some important features of the corresponding non-amplified handles, and finally to help the user achieving its task better. The feedback provided to the user by such an active handle is also called force feedback. A classical example is the aircraft pitch control, where artificial vibrations are generated to mimic the behaviour of non-amplified handle in case of a dangerous state in the aircraft, which the pilot should be as intuitively as possible warned of. This type of force feedback is also used in training simulators, in some today's interactive games, etc.

In this case, the force feedback is not correlated directly to the forward signal, nor sensed on the distant controlled process, like in teleoperation. Also, it is not a mean to implement a physical full coupling. Various studies show however that the effect on the user can be efficient, in terms of believability, even though the coupling of the generated feedback with the distant controlled process

is not physically valid. However, since the resulting effect for the user is necessarily active (some energy is introduced in the interaction), obtaining a believable effect when using this type of feedback necessitates that the process controlled through the handle is itself an active system (able to generate energy).

Force-feedback device

Finally, a more recent usage of the term, which is particularly important in the domain of Enactive Interfaces, concerns the so-called force feedback devices, that are a major subclass of the Haptic devices. However, in the case of these devices also, the term force feedback is somewhat unclear. It can refer to the stimulation of human kinaesthetic perceptive system [Burdea, 96] [Ellis, 95] - which is somewhat doubtful since human haptic interaction cannot be reduced to a simple forward / backward model. But it can also refer to the control structure of the device itself, in the case when the actuator is designed as a force actuator [→ Effector] – which is, indeed, not always the case in this type of devices that are often actually designed as force sensors/position actuators. Following this introduction, a more detailled discussion on the concept of force feedback device is presented in [→ Haptics, haptic devices].

References

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