Tactile-force-feedback integration as an exemplary case for the sense of touche in VE. A new T-FFD device to explore spatial irregularities

Jean-Loup Florens, Armen Khatchatourov, Charles Lenay, Annie Luciani, Gunnar Declerck

Tactile-force-feedback integration as an exemplary case for the sense of touch in VE. A new T-FFD device to explore spatial irregularities.

Jean-Loup Florens*[1]*, Armen Khatchatourov*[2]*, Charles Lenay*[2]*,
***Annie Luciani*[3] *& Gunnar Declerck*[2]**
[1]ACROE, France
[2]COSTECH, Technological University of Compiègne, France
[3]ICA, INPG, France
jean-loup.florens@imag.fr

Context

The tactile-force-feedback (T-FFD) integration is pertinent for (at least) two situations in which the role of tactile should be explored:
- Grip control in tasks of prehension
- Exploration of spatial irregularities

In each of these tasks, the complexity of interaction results in two major questions which should be explored:
- The question of the role of deformability of the exploratory body creating dynamic constraints on the user's movement (deformation of the exploratory body in the model implemented and information on this deformation brought to the user through the tactile stimulation).
- The question if an addition of tactile information can overcome the "one-point" characteristic of FFD: if a spatially distributed information on the environment, combined to one-point force interaction, can be approached to the spatial distribution of forces in real situation.

Thus, we have identified and have begun to explore 4 major cases in which the T-FFD integration is important. In the following table, 2 rows and 2 columns define 4 cells and 4 major cases to be explored. The experiments/devices numbered from 1 to 4 are positioned with regard to these 4 cases of T-FFD integration.

1 The experiment already conducted at COSTECH: The role of tactile augmentation of a PHANToM FFD studied on a task of goal-directed displacement"

2 TactErgos device: physically based modelling of interaction; deformable exploratory body; synchronous functioning.
Pilot experiment: The role of tactile augmentation of a FFD interaction studied on a task of goal-directed displacement.

3 4 Further work.

	Proprieties of the model and the interface	
Interaction with environment	**Deformable body**	**Spatial information**
Exploration of spatial irregularities	2	1
Grip Control	3	4

Tactile-force-feedback device: TactErgos

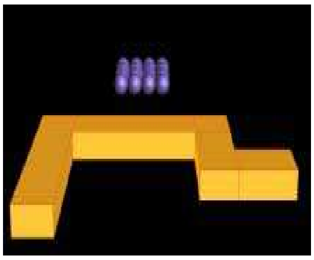
We have developed and will present a T-FFD device with following features:
- it is based on ERGOS force-feedback device, driven by TELLURIS synchronous real-time processor (both developed by ACROE-ICA)

- the scene is modelled using physical modelling (CORDIS formalism), i.e. by masses connected to each other by springs. This allows to easily model deformable objects and deformable exploratory body.
- tactile stimulation is realised by Braille cells. Each of 16 pins is independently activated when the force circulating between the one corresponding mass composing the exploratory body and the object is above a certain threshold.
- the activation of pins is integrated in the force-feedback calculus loop allowing a synchronous functioning at 3kHz (refreshment of stimulation is cadenced at the frequency of calculus of the physical model). At each calculus step, the 16-pins data is serialised down to 4-bit and send to the electronics of Braille cells through the parallel port interface of VME bus, piezoelectric stimulation being limited to 500Hz.
- the resultant of forces of interaction between the masses of the body and the object constitutes a material constraint to the displacement of the body, and is transmitted to the user through the grip of FFD device.

The main novelty of the device is that the tactile stimulation is obtained strictly from the same interaction loop, and obeys to the same physical formalism, as the FF. Thus, it provides both the information on the spatial distribution of forces circulating between the object and the body (activation of tactile pins); and also permit to implement the deformable body.

A pilot experiment

A pilot experiment is currently conducted and will be presented. It goes on a task of goal-oriented displacement without vision: following the contours of a virtual rigid bridge to reach its end.



A similar experiment has already been performed at COSTECH, using a TactoPHANToM device (tactually augmented asynchronous PHANToM device, no deformation of exploratory body). In this COSTECH's experiment the display of tactile information improves the contour following of the resistant structure (there's a substantial decrease of number and time of contact losses, which means that the adhering to the bridge is better): subjects are able to use the tactile information to efficiently guide their displacements along the resistant surface.

This will allow a comparison between two devices, and elicit the role of deformation of exploratory body.

Future work

Future work will be directed towards exploration of the grip control where both the deformation of the exploratory body and the spatial information seems to be important.

References

Declerck, G., & Lenay, C. (2006). The role of tactile augmentation of a PHANToM FFD studied on a task of goal-oriented displacement. An enactivist contribution to the study of modes of control of haptic interactive displacement. 2nd Enactive Workshop – Montréal.

Jansson, G., Billberger, K., Petrie, H., Colwell, C., Kombrot, D., Fänger, J., König, H., Hardwick, A., & Furner, S. (1999). Haptic virtual environment for blind people: exploratory experiments with two devices. *International journal of virtual reality, 4,* 10-20.

Lederman, S. J., & Klatzky, R. L. (2004). Haptic identification of common objects: Effects of constraining the manual exploration process. *Perception & psychophysics, 66(4)*, 618-628.

Uhl, C., Florens, J. L., Luciani, A., & Cadoz, C. (1995). Hardware Architecture of a Real Time Simulator for the Cordis-Anima System : Physical Models, Images, Gestures and Sounds. Proceedings of Computer Graphics International '95 - Leeds (UK). Academic Press. - RA Ernshaw & JA Vince Ed. - pp 421-436.

ENACTIVE

costech

utc Université de Technologie Compiègne

INP Grenoble

ENACTIVE 06

Tactile- force-feedback integration as an exemplary case for the sense of touch in VE. A new T-FFD device to explore spatial irregularities.

Jean-Loup Florens[1], *Armen Khatchatourov*[2], *Charles Lenay*[2], *Annie Luciani*,[3] *Gunnar Declerck*[2]
[1]ACROE, [2] COSTECH, UTC, [3]ICA, INPG
jean-loup.florens@imag.fr

ENACTIVE

Introduction

• The tactile-force-feedback (T-FFD) integration is relevant for (at least) two situations in which the role of tactile should be explored:
- Grip control in tasks of prehension (tactile as control of force)
- Exploration of spatial irregularities

ENACTIVE

Introduction

In each of these tasks, the complexity of interaction results in two major questions which should be explored:

• *The role of deformability of the exploratory body*

It creates dynamic constraints on the user's movement
It is able to bring specific information

⇒How to implement the deformation of the exploratory body
⇒How to bring information on this deformation to the user through the tactile stimulation.

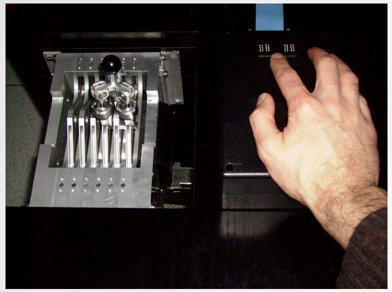
• *Is the addition of tactile information able to overcome the "one-point" characteristic of Force Feedback Devices*:

In "real" situation: spatial distribution of forces.
Can we approach it if a spatially distributed information on the environment is combined to one-point force interaction?

ENACTIVE

Tactile-force-feedback device: TactErgos.

- The scene to be felt is modelled using physical particle modelling (CORDIS formalism), based on masses-interactions. This allows to easily model deformable objects (as for ex. deformable exploratory body) and physical interactions.

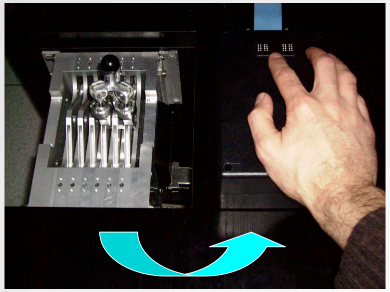


- The FFD is based on high fidelity ERGOS force-feedback device, driven by TELLURIS synchronous real-time processor, both developed by ACROE-ICA

ENACTIVE

Tactile-force-feedback device: TactErgos.

- The tactile system is based on Braille Cells. Each of 16 pins is independently activated when the force produced by the physically-based simulation is above a certain threshold.



- The activation of pins is integrated in the force-feedback calculus loop allowing a synchronous functioning at 3kHz (refreshment of stimulation is cadenced at the frequency of calculus of the physical model), i.e. what it is sent to the tactile stimulation corresponds at each sample rate to what it is acted and sent from and to the FFD.

ENACTIVE

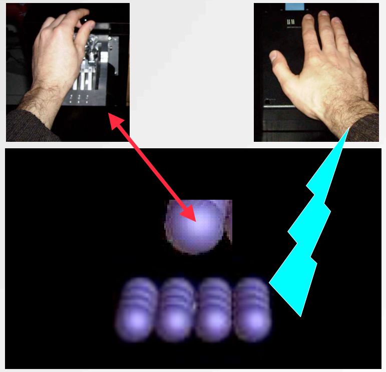
Experiment n°1

Exploration of a "textured surface"

- With the FFD
- And with the addition of the tactile (Braille cells...)

- We move on the surface with the FFD.

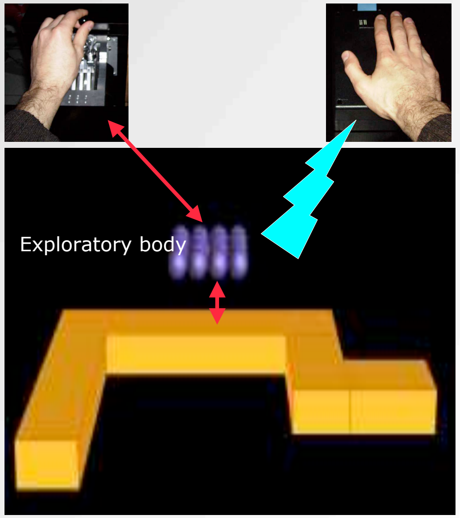
- When the relief is revealed (felt) through the FFD, the Braille Cell are activated



ENACTIVE

Experiment n°2

- The exploratory body is composed of a grid of 16 masses
- Each of 16 masses is in elastic collision interaction with the object that simulates a vertical deformation of the Exp. body.
- The resultant of forces of interaction between the masses of the body and the object is transmitted to the user through the grip of FFD device.
- *tactile stimulation* is activated when the force circulating between the points of the exploratory body and the object is above a certain threshold.

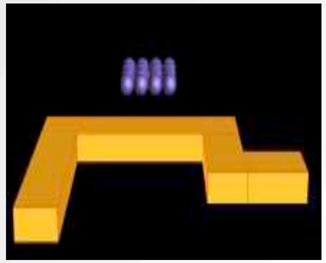


ENACTIVE

Comparison

A similar experiment, called TACTOS 3D, has already been performed by Declerck, G., & Lenay, C., (2006). , using a TactoPHANToM device (Experiment 0).

Experiment 0 - TACTOS 3D



The activation of the Braille pins are triggered by the position of the exploratory body, not by the force of contacts acted by the FFD.

All the action and feedbacks are not synchronized

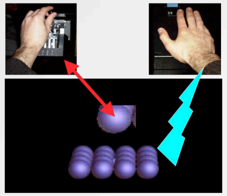
Comparison

The main novelty of the TactERGOS is that the tactile stimulation

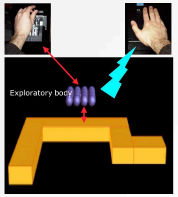
- is obtained strictly from *the same synchronized interaction loop*, and
- obeys to the same physical formalism, as the FF.

Thus, it provides both the information on the spatial distribution of forces circulating between the object and the Exp. body and it also permits to implement the deformation of the body.

Experiment 0 - TACTOS 3D



Experiment 1



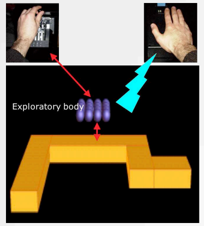
Experiment 2

TactERGOS

Comparison

- In Experiment 0 “TACTOS 3D”, the “staying on the bridge” is improved by the display of tactile information (decrease of number and time of contact losses).
- In Experiment 2 “TactERGOS”, the manipulation is very accurate (force, displacements) and in that stage of our experiment, we cannot affirm that the following of the bridge is better.

Experiment 0

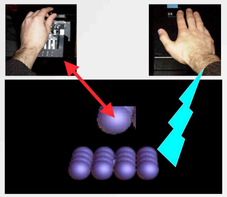


Experiment 2

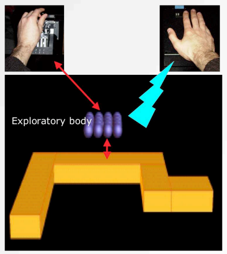
Comparison

Preliminary rough observations

- In Experiment 1, Tactile information is trivially non relevant. Conversely, information conveyed by the correlated action-perception via the FFD is very impressive and it is widely sufficient for the feeling of the textured surface. The “thing” is mainly felt through the FFD.
- In Experiment 2, something on “**new**” is happening. The FFD seems to work at the level of “sensation” although the “tactile” reveals strongly the emergence of the “felt thing”. The feeling of the “thing” seems transferred from the FFS to the tactile.



Experiment 1



Experiment 2

Conclusion

We based this modelisation on hypotheses (different from Costech’s ones - Experiment 0)*:*

- Tactile is sensible to forces
- It informs on potential deformation of the body
- It informs on spatial configurations...

- *But why not others?*
- tactile as sensible to the torque (6DoF vs. 3DoF)
- tactile as sensible to the displacement (skin stretch)

ENACTIVE

Conclusion

Our general conclusion is the respective "role" of tactile and FF will depend on the model.

- As: (1) T is in itself heterogeneous and (2) T-FF synergy is not fixed: no rigid threshold between tactile and force perception)
  - → Lack of hypotheses
  - → Intrinsic difficulty to design a relevant model
- T-FFD integration raises the question of model to implement
- In general, not prejudge on the role of the tactile/ FF, rather to be attentive to new experiences.

ENACTIVE

Thanks for your attention