Extending the Human Perception and Action: Graphics, Visualization and Interaction Lab at UFRGS

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Figure 1: A mosaic with some of the works recently developed, including: the immersive risk simulator in use, the LOP-cursor and disambiguation canvas for 3D interaction with data, the haptic language proposed by us, and the test of new interaction techniques in the medical domain.

**HIGHLIGHTS**

Active for more than 30 years, the lab is the largest graphics research group in South America. The Lab focuses on interactive visualization and simulation, but holds strong expertise in most graphics related areas due to the varied background of its members and permanent external collaboration. Our computer science graduate program is now (since 2014) ranked among the top 5 in Brazil. This gives us the perspective of substantial funding increase, allowing us to attain international quality in our research in a near future.

1 **RESEARCH FOCUS AND STRATEGY**

The Graphics, Visualization and Interaction Lab at the Federal University of Rio Grande do Sul (UFRGS) started its activities in 1978 developing research mainly on rendering and animation. By the end of the 90s, the group started to grow, aggregating new researchers with different expertise. New research topics and application areas such as image acquisition and analysis, virtual reality, and visualization of complex data started to be investigated. Many techniques developed by the group became interactive and research efforts started to include different interaction techniques, exploiting the use of non-conventional devices and techniques to allow easy manipulation of virtual objects as well as natural navigation in information spaces.

As graphics and image research is a very dynamic environment, the group defines itself today as an interactive visualization research group, where visualization goes beyond the eye to include the touch and auditory systems. Our mission is then to use the most out of the computational resources available to enhance human activity with all helpful sensory (not only visual) information in harmony with our living environment while bearing in mind the human tasks the systems are entitled to support. Such goal touches a number of computational and human aspects, which are covered at the projects in the different research lines pursued by the group members.

In a quest for mechanisms to enhance the human with computers, we have been investigating new technologies and techniques that may contribute to extending the human perception and to enlarge our power of action. Such strategy is coupled with the concepts of calm and natural interfaces, where computers become ubiquitous and users live in a fully connected world, being constantly updated through their senses and acting in a precise and natural way. In order to accomplish our goals, we are conducting research on HCI, virtual and augmented reality, as well as in the use of mobile devices to allow the implementation of these concepts everywhere. Results achieved are being tested in real applications (e.g. visualization and medicine) and with final users whenever possible.

2 **RECENT ACCOMPLISHMENTS**

Here we overview some results that illustrate the above.

2.1 **HCI and 3D Interaction**

We have recently proposed a family of 3D interaction techniques based on smartphones for 3D selection and manipulation. The use of such devices presents two advantages: they are equipped with a rich set of sensors and fit greatly as pointing devices; almost everyone has a smartphone and carries it always and everywhere as an extension of their own body.

While pointing is, in general, inaccurate, especially with ultra-resolution displays, our level of precision (LOP) cursor [4] provides two levels of precision relying on the device’s touchscreen for disambiguation. It provides a constrained area of high-resolution input and a broader area of lower input resolution, offering also the possibility of work with a two legs cursor using only one hand. Results have shown that targets smaller than 0.3 cm can be selected on a tiled display by users at distances over 1.5 m from the screen with minimum effort.

The technique has been extended to immersive 3D environments, where a disambiguation canvas [2] has been proposed to offer pre-
cise and fast selection. Disambiguation canvas also relies on the sele-
cation by progressive refinement. In the first step, the user defines
a subset of objects by means of the orientation sensors of the smart-
phone and a volume casting pointing technique. The subsequent
step consists of the disambiguation of the desired target among the
previously defined subset of objects. Relying on the touchscreen,
the user can disambiguate among hundreds of objects at once. User
tests show that our technique performs faster than ray-casting for
targets with approximately 0.53 degrees of view angular size and is
also much more accurate for all the tested target sizes.

2.2 Immersive Simulators and Human Factors
Besides hardware limitations, low usability is a major factor pre-
vanting the widespread use of immersive simulators for training,
planning and evaluating human abilities. As immersive systems are
a tremendous field for studying human factors, we are conducting
efforts toward usable interfaces for VR simulators. In a recent work,
we describe alternative designs to control locomotion in a simulator
to assess risk perception in dangerous working places.

We demonstrated how user performance relation to the number
degrees of freedom varies with the cognitive load of the task [6].
Currently, we are evaluating the same system with real workers.
Next steps involve the use of a similar system to detect different
users’ profiles, as well as the implementation and test of such a
system on a mobile platform to allow higher scalability.

2.3 Haptic Interaction
Besides the touch and force feedbacks felt when touching or grasp-
ning objects, ad hoc tactile signals have successfully been used, for
example, as small vibrations that signalize an incoming call or mes-
sage by a cell phone. We are working to extend such simple vibra-
tory notifications so that they are modulated in sets of lexical tactile
elements (so called tactons) that, put together in sentences, com-
pose very expressive languages. One thing we have found out is
that to increase the language expressiveness without increasing the
number of ad hoc tactons, modifier tactile patterns can be used [1].
Perceptual and cognitive factors such as stimuli type and location
on the body are some current foci of study.

3 APPLICATION AREAS
Our research is also strongly guided by real problems with direct
application in different areas. In this section, we highlight two of
them.

Medicine A great motivator of our research on VR is the med-
cical field, especially VR-based surgery simulators. We have first
worked on techniques for modeling organ shapes, joint motion,
and tissue deformation. Then we explored collision detection and
instrument-tissue interaction, and put that all together in a software
framework based on game engines [7]. Currently, the main chal-
genest reside on: creating customized patient models for surgery
planning, providing physically based lighting to simulate real tis-

sue, and proposing new interaction techniques to explore medical
data.

Visualization Since the 90s, we develop research on scientific
and information visualization. Then, the proposal of new strate-
gies to interact with data was a natural evolution for us in this field.
Both 3D interaction techniques presented in the previous section
were designed to be used with data visualization and are now being
adapted to be tested with real users to solve interactive visualization
questions. New tools have been proposed to manipulate 3D images
obtained from CT [5] using one or two hands. More recently, we are
also exploring the use of mobile display devices for volume visual-
ization, allowing augmented reality views directly on the patient’s
body [3].

4 UNIQUENESS
Several factors collaborate to compose our uniqueness in the re-
region and our potential to produce excellent research comparable
to top ranked international institutions. According to the Brazilian
Ministry of Education, UFRGS is ranked among the top 5 research
universities in Brazil. Its Computer Science program is reputed the
number one by the same ministry and recognized by the industry for
the excellent education provided. Our Graduate Program in Com-
puter Science is also one of the largest, covering most of the ar-
eas. This entitled us to count on an attractive infrastructure and a
significant number of undergraduate and graduate research scholar-
ships. Currently, around 40 undergraduate, master and Ph.D. stu-
dents work in our lab in a daily basis, exchanging experiences and
taking advantage of the same facilities. Six professors compose the
Graphics, Visualization, and Interaction Lab. They have a var-
tied background for having obtained their Ph.D. or having spent a
post-doc time in different, highly qualified institutions worldwide,
having maintained cooperation projects with reference international
groups along the years.

Due to these characteristics, the group welcomes MSc and Ph.D.
students with varied backgrounds but with strong evidence of a
research-oriented profile, and also seeks collaboration with other
groups to broaden research opportunities.

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