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TANGIBLE COCKPIT

Exploring the Physical Design Space for Situation Awarness and Performance in the Interactive Cockpit

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TANGIBLE
TRANSFORMABLE
SURFACES
HAPTIC
BODY CENTRIC
ORGANIC
TACTILE
SMART MATERIAL

FROM AERONAUTICAL PROBLEMS TO RESEARCH ISSUES

WE EXPLORE the design space for interactive instruments in the cockpit of the future.

Touch technologies are going to replace current electronic displays for flying and navigating instruments. Although such options bear obvious advantages such as a dynamically reconfigurable cockpit, getting rid of the physical knobs and switches, it is not without introducing strong drawbacks such as the lack of references or physical feedback. For safety and performance reasons, interactive instruments should maximize the perception, action and collaboration spaces of the pilots, and the literature highlights the limits of touch interaction as for these aspects.

OUR OBJECTIVE is thus to explore how the ***physicality of interactive technologies*** could address this issue. Based on a set of elicited requirements for interactive instruments in the cockpit, that were iteratively elaborated through previous work, contextual interviews and workshops, we explore the literature on tactile, haptic, tangible, gesture-based, organic and smart material based interaction along a multi-dimensional design space, based on ***shape***, ***embodied perception/action*** and ***programmability***.

WE MAP our **elicited requirements** to *known properties* in each design dimension. For each mapping, we indicate the requirement and specify the associated **design principle**.

a.) Alexander, J., Lucero, A. and Subramanian, S., Tilt display demonstration: a display surface with multi-axis tilt & actuation. MobileHCI 2012.
b.) Gustafson, S., Rabe, B. and Baudisch, P., Understanding Palm-Based Imaginary Interfaces: The Role of Visual and Tactile Cues when Browsing, CHI '13.
c.) Leitner, J. and M. Haller, M., Geckos: Combining Magnets and Pressure Images to Enable New Tangible-object Design and Interaction, CHI '11.
d.) Harrison, C. and Hudson, S. E., Providing Dynamically Changeable Physical Buttons on a Visual Display, CHI '09.

COGNITIVE REQUIREMENTS

R.C.1 direct localization perception
Even for experts, flying feels like being in a "non-usual" universe: you are in the middle of the sky, without any landmark, so you do not immediately know "where you are". For this purpose, pilots need devices providing few and directly available parameters

R.C.2 situational awareness
Pilots need to be able to both get information related to the context of the flight and to predict the state of the system with respect to e.g. autopilot, in order to avoid cognitive conflicts and anticipate actions

R.C.3 collaborative awareness
Major procedures must be collaboratively performed and each individual pilot action needs to be shareable and visible to the other

R.C.4 operational performance
Devices and interactors should show a high degree of usability, for instance to enable the selection of discrete values while not requiring too much focus; these devices should provide perceptible feedback or on the opposite prevent non reversible action

R.C.5 degraded context
In the cockpit, both environmental and cognitive factors can dramatically degrade the performance of human operators. For example, extreme lighting conditions, vibrations or degraded flying conditions, but also cognitive overload, might greatly downgrade efficiency. This requires to include adapted interactive solutions from the start of the design process.

INDUSTRIAL REQUIREMENTS

R.I.3 configurability
Interactive components should dynamically adapt to numeric information flow (hence the progressive introduction of software components).

R.I.2 development
Display and flight components should be less expensive to design, develop and certify.

R.I.1 dynamicity & adaptability
To reduce costs, suppliers promote the design of new product lines adaptable to different aircraft programs. Industrials thus seek technologies that are flexible enough to enable inexpensive components reuse and reconfiguration.

SECURITY REQUIREMENTS

R.S.3 availability
Redefining the cockpit interactive components forces us to re-examine availability and accessibility issues. For instance, interface elements must be dynamically adapted to the phase of the flight. Mobile, or detachable objects raise a challenge both as potential dangerous projectiles and as unreachable elements.

R.S.2 resilience
The robustness of interactive systems is required in relation to various potential breakdowns or vulnerabilities regarding power, light, visibility (smoke), noise, etc. Techniques and modalities used (e.g. for alarms) must support critical context and enable alternative modes.

R.S.1 safety-critical system
The certification process imposes to comply specific standards, requirements or processes such as RTCA DO-178B on safety of software used in airborne systems, and to use formal methods to describe advanced interactions in the cockpit

DEVICE SHAPE PROPERTIES

graspability
- R.C.4 not too much focus
- R.S.2 alternative modes
- R.S.3 availability

dangerous projectiles
- R.S.1 safety

visibility in physical space
- R.C.1 R.S.3 easy&direct access
- R.C.3 shareability
- R.C.2 contextual awareness

eyes-free interaction
- R.C.5 robustness

various cockpit geometries
- R.I.1 adaptability
- R.I.2 reusable shapes
- R.I.3 customer needs

PROGRAMMABILITY

filtering
- R.C.4 simplification

software and physical dynamicity
- R.C.4 R.C.5 coherence physical - digital
- R.I.1 adaptability
- R.C.2 R.C.3 contextual information
- R.C.4 end-user configuration
- R.S.1 adapted constraints
- R.S.2 alternative modes
- R.S.3 availability given phase of flight
- R.I.2 cost effective
- R.I.2 reprogrammable

synthetic 3D view
- R.C.1 reduce perceptual distance

EMBODIED PERCEPTION & ACTION

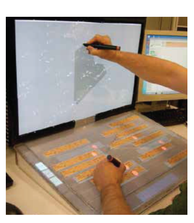
non-fragmented visibilty
performative actions
- R.C.3 comprehensibility

universality of sensorial perception
- R.I.2 fewer training
- R.I.2 universality

body parts availability and accessibility
- R.C.5 degraded context
- R.C.1 R.S.3 accessibility
- R.S.2 resilience

haptic, palm, fingertip
- R.C.4 perceptive feedback

physical constraints
bimanual gestures
proprioceptive perception
- R.C.1 R.C.4 physical performance directness



Laboratoire d'Informatique Interactive (LII)
a research laboratory of the French aviation university

The ENAC's Interactive Computing Laboratory carries out research on key fundamental issues in the design, engineering and production of critical interactive systems such as those encountered in aeronautics.

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IMMERSION
imagination, interaction…

European expert in innovative, immersive and collaborative 3D technologies, in the fields of industry and research. Immersion develops and integrates high-end display systems and interaction devices, in order to test, design, simulate and agree in real-time around the virtual mock-up.

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DESIGNUMERIQUE

Astrolab design user-centered services for the web, mobile, television, connected objects and places. Astrolab is specialized in UX design and innovation consulting.

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