Usability Evaluation of Multi-Touch-Displays for TMA Controller Working Positions

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Knowledge for Tomorrow
• SESAR WP 10.10.02 “CWP Human Factors Design”
• Task “Innovation Analysis Report 2013”,
  • Focus on interaction technologies:
    • Multi-Touch
    • Eye Tracker
    • Handwriting Recognition
• Our investigation subject
  • Compare multi-touch with mouse interaction
**Motivation**

**State of the Art**

**Advantages of multi-touch**
- Reduced selection time, direct-touch of object
- Bi-manual gestures enable faster trigger of actions
- Hedonistic user experience
- No intermediate device
- Easy and fail-safe
- Possibility for intuitive design
- Potential for collaborative use at big screens

**Disadvantages of multi-touch**
- Lack of preciseness
- On large displays reachability may be bad
- Target objects may be hidden by hand
- Visual and haptic feedback is missing
Mouse HMI is used as reference

- Is multi-touch really faster than mouse?
- Is it more intuitive?
- Is multi-touch suitable for the feeder controller working position?
- Do controllers appreciate direct manipulation of aircraft objects?
Multi-Touch HMI compared to mouse HMI:

1. Mental workload will be lower
2. Physical workload will be higher
3. General usability will be higher
4. User experience will be higher
5. Controller performance will be higher
RESEARCH PROTOTYPES

Multi-Touch

Option Wheel

Area Selection

Reduce Command

Descend Command
RESEARCH PROTOTYPES

Multi-Touch

Handover Button

Turn-to-Base Command

One Hand Distance Measuring

Two Hands Distance Measuring
RESEARCH PROTOTYPES
Same selection of commands and functions, interaction by:
- left click,
- right click,
- mouse wheel,
- menus
METHODS

Experimental Setup

Display for
- traffic situation overview
- AMAN sequence/runway allocation advisory

Multi-touch interaction device for
- section of traffic situation
- AMAN sequence/runway allocation advisory

Working position is standing upright

Display for
- traffic situation overview
- AMAN sequence/runway allocation advisory

Mouse interaction device
Working position is seated
Simulation of Frankfurt Approach:
- Airspace structure 2010, 2 parallel dependent runways
- Realistic traffic with medium task load
- Data link communication assumed
- Simulated ideal pilots reacting without delay
- Same scenario for simulation runs with different input devices
- Controller task required:
  - Compact sequence on centerline
  - Compliance to separation rules

- Limitations:
  - Small amount of possible commands
  - No corrections in final phase by tower controller possible
### Metrics

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<td></td>
<td>• Separation accuracy</td>
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<td>• Number of landings during trial</td>
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<tr>
<td></td>
<td>• Separation violations</td>
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Investigation Setup:
- 7 days of trials
- Participants: 14 controllers from DFS,
- 7 TMA, 7 en-route controllers,
- 2 female, 12 male
- 2 participants on every day, one starting with multi-touch, the other with mouse to avoid sequence effects

Time schedule test run for each device:
- 10 min. training session
- 25 min. trial session
- Debriefing
RESULTS

Conclusion

Workload

Usability

Controller Performance

User Comments

System Usability Scale

Usability Questionnaire

Conformity with user expectations

Error tolerance

Suitability to the task

Controllability

Suitability for individualisation

Self-descriptiveness

working posture relaxed

Level of Agreement

(1 = I don't agree at all, 5 = I totally agree)
Simulation Data Conclusion for Controller Performance

![Simulation data results](image-url)
Cons:

- Touch accuracy is sometimes a problem when selecting moving objects
- Information on screen was sometimes covered by menus, too big icons, or by hands
- Some controllers did not like a two display concept
- Infra-red based multi-touch sometimes produced unwanted ghost touches
- Ergonomic problems, e.g. arms fatigue, could arise when working for a longer period of time
Pros:

- Gestures are innovative and intuitive
- Analogies used for the implementation of commands are more easily understood and memorized
- The infrared technology allows comfortable and smooth input with the fingers
- The abortion of an action and restart of a new action was very fast
- Not many unintended actions occurred
- Direct touch philosophy is easy to apply
- Multi-touch is safer because of being easier to use
CONCLUSION

Hypotheses Assessment

1. Mental workload will be lower
   • Mental workload and effort rated lower in NASA-TLX

2. Physical workload will be higher
   • Upright position leads to higher physical workload

3. General usability will be rated higher
   • Investigated multi-touch implementation is well-accepted
   • Rated as excellent because of intuitive and fast gestures
   • Individualization is rated as poor

4. User experience will be rated higher
   • No clear difference can be extracted

5. Controller performance will be higher
   • Choice of interaction technology does not influence controller performance significantly

Outlook

Highlights

> Usability_Multi-Touch_Displays > Maria Uebbing-Rumke • Sesar Innovation Days 2014 > 2014-11-26

www.DLR.de • Slide 20
Multi-touch implementation in the experiment is found to be:

- no show-stopper due to safety issues
- imaginable at the working position
- error tolerant
- quick
- efficient
- hardly influencing performance of the controller, even at this early stage
Recommended extensions of the multi-touch operations:

- Implementation of complex commands (command chains)
- Design of intuitive gestures for complex commands
- Integration of MT device in ergonomically designed furniture
- Use of navigation gestures known from consumer devices for zooming and panning
CONCLUSION

• **First study** investigating a gesture language for CWP functionality

• Developed **innovative and intuitive gesture interaction concept** for approach control

• **Usability** of multi-touch rated **significantly higher** than mouse

• Controllers’ feedback:
  
  **Multi-touch interaction technology ready for use** at daily work
Thank you for your attention

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