

User Performance in Relation to 3D Input Device Design



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- ❑ Studies conducted at University of Toronto
- ❑ Usability review of 6 degree of freedom (DOF) input devices for 3D interfaces.

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SLIS, Indiana University*

Topics

- ❑ Performance Measures
- ❑ Mouse based 6 DOF interaction
- ❑ Mouse modification of 3D interfaces
- ❑ Free moving isotonic devices
- ❑ Form factors of control handle
- ❑ Desktop isometric & elastic 6 DOF devices
- ❑ Position vs. Rate control
- ❑ Armature based 6 DOF devices

Performance Measures

- ❑ Based on
 - Speed
 - Accuracy
 - Ease of Learning
 - Fatigue
 - Coordination
 - Device persistence & acquisition

Coordination

- To achieve proportionate motion
- To time movement towards the final position
- Measurement based on the ratio of actual to coordinated space trajectory

Device persistence and Acquisition:

- Cursor maintains position on release of the device
- Comfortable to reach
- Time required to perform skillful operation

Mouse based 6 DOF interaction

- ❑ Mouse Mapping
 - To control motion in 6 DOF using 2D interacting device
 - 6 graphical sliders are needed on the screen
 - Sliders facilitates motion along and about all axis

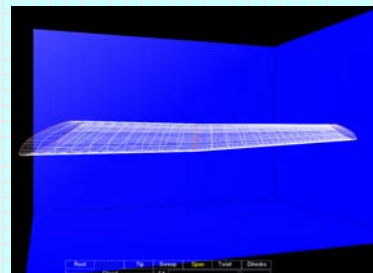


Usability Issues

- Difficult to mentally compute orientation along 2 different axes
- Time multiplexing issues leads to lack of coordinated movement

Improved technique

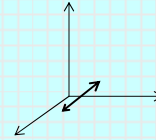
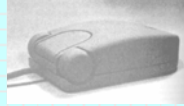
- Manipulating the 3D object with a virtual sphere



Mouse modification of 3D interfaces

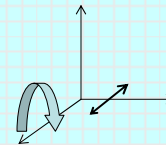
❑ Roller Mouse

- Introduces motion along the 3rd axis
- Does not cover the rotation about the axes



❑ Rocking Mouse

- Rocking motion introduces additional motion
- 2 additional DOF compared to normal mouse mapped onto z dimension



Details

❑ Isotonic Devices

- Also called as displacement devices
 - Free moving devices
 - The displacement of these devices is mapped to cursor movement
- E.g.: Flying Mouse

❑ Isometric Devices

- Also called as pressure devices or force devices
 - These devices sense forces but do not perceptibly move
 - Force or displacement is mapped to the velocity, implies rate controlled
- E.g.: Desktop devices

Free moving isotonic devices

- Flying Mice
 - To rotate and move in air for 3D manipulation



The "Bat" - designed by C. Ware



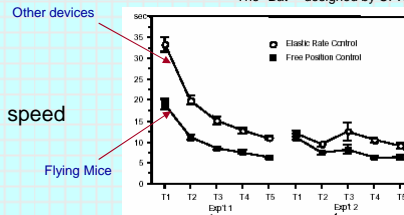
The Cricket - manufactured by Digital Image design Inc

Advantage

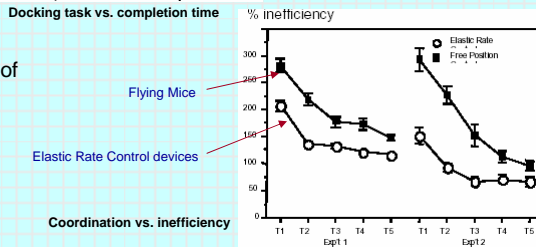
- Easy to learn
- Fast operational speed

Disadvantage

- Limited range of motion
- Anatomical limitation cause lack of coordination
- Cause fatigue
- Lack persistence on release



The MITS Glove



Form Factors

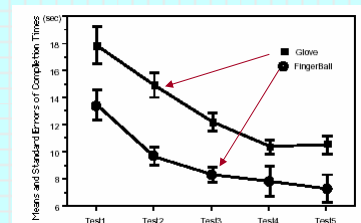
- Size & Shape of the device



Fingerball

- Advantage in motion over gloves
- Higher range of motion – Wrist & Fingers
- Higher rotating angle
- Greater range of DOF achieved

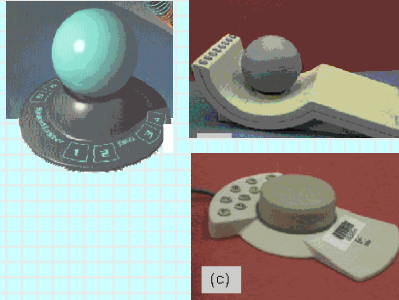
* On account of higher range of motion, the error introduced in performing a task is minimized



* Performance difference in terms of error in completing the task
Finger ball vs. glove

Desktop isometric devices

- Mounted on stationary surface
- Operate in rate control mode
- Self-centering mechanism



Advantages

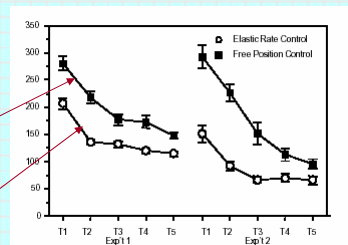
- Cause less fatigue
- Improved coordination
- Steady & smooth cursor motion
- Higher degree of persistence

Disadvantage

- Takes time to perform skillful operations
- No feedback to control performance due to rigid structure

Flying mouse
(Isotonic Devices)

Desktop devices
(Isometric devices)



Elastic Devices

- Devices with variable resistance
- Spring loaded system
- Moves in proportion to the force applied
- Self centering mechanism

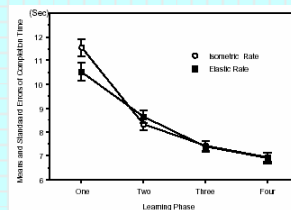


Advantage

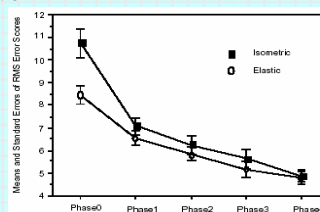
- Strong feedback obtained, since pressure and displacement sensed

Disadvantage:

- More force leads to compromise the self centering mechanism
- More force leads to less rate control compatibility



Completion time vs. learning phase



Tracking Error

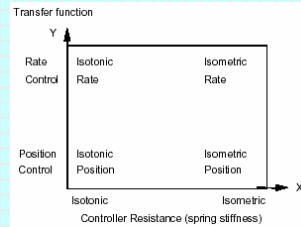
Position vs. Rate Controlled Devices

Position control devices

- Operator controls the object positions directly
- Transfer function is a constant
- Isotonic devices (e.g. flying mice)

Rate control devices

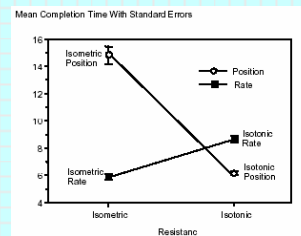
- Maps human input to velocity
- Transfer function is an integral
- Isometric devices (e.g. desktop devices)



Experiments to use isotonic devices as isometric devices and vice versa

- Isotonic : zero or constant resistance
- Isometric: infinite resistance

Results: Poor performance



Armature based devices

- Involves mechanical arm
- Hybrid of desktop & flying mouse
- Good with character posing applications



Advantage

- No electromagnetic interference as the flying mouse
- Fast response
- If joint control available, good device persistence and acquisition

Disadvantage

- If joint control not available, fails in device persistence
- Causes fatigue
- Operational limitation owing to cables

Conclusion

- ❑ Some complexity involved in 6 DOF is explored
- ❑ Inference drawn that:
 - For speed & short learning - Isotonic devices useful
 - For low fatigue, trajectory quality & coordination – Isometric devices useful

Discussion:

The presentation was followed by a short discussion session to answer some queries

- ❑ Functioning of the Isotonic devices (E.g.. Flying Mouse): This query was answered by referring to the related slides and explanation of using a magnetic tracking system
- ❑ To get an idea about the knowledge depth acquired by the audience on this topic. A question about Which class of devices does the Flying Mouse belong to was asked. The audience was quick to respond with the correct answer: Isotonic Devices

- ❑ The presentation slides were forwarded to author and originator of this article. The feedback received was:

“ I took a quick look and was very impressed.”

- Shumin Zhai, Ph.D