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## Predictive Interaction using the Delphian Desktop

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## BACKGROUND

- PC's Display
  - Large size
  - Large resolution



↓

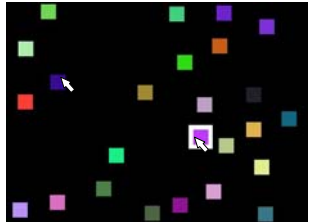
Increase of the pointing time and user's load  
in WIMP interface

→ Development of pointing support system

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## RELATED WORK (1/3)


- Object pointing [Yves Guiard , et al. ,2004]
  - Cursor jumps to the nearest target according to cursor movement angle



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## RELATED WORK (2/3)


- Expanding target [M.McGuffin, R.Balakrishnan, 2002] [S.Zhai , et al. , 2003]
  - Target is expanded immediately before cursor approaches to click it easily



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## RELATED WORK (3/3)



- Semantic Pointing [Yves Guiard , et al., 2004]
  - Control-Display ( C-D ) is changed according to the distance to the target
    - Vicinity of Target : C-D ratio increase (slow)
    - Not vicinity of Target : C-D ratio decrease (fast)



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## POINTING SUPPORT APPLICATIONS

- Smart move (Windows Me)
- Snap to default (Windows XP)





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## PREDICTIVE INTERFASE

If user's spatial intention can be **predicted** before completing the pointing task,

- Possible applications
  - Cursor jumps to the predicted target
  - Execution of application before expected click
  - Expand the region of targets to click it easily
- Possible effect
  - Reducing of pointing time and user's load



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## PREDICTIVE INTERFASE

- Related work
  - Object pointing
  - Expanding target
  - Semantic pointing
  - etc..
  - Using only static relation between cursor position and target position
  - Not target prediction

↓

- Proposal
  - Using kinematics features during pointing task for **prediction** of user's goal ( cursor velocity etc.. )

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## PECEPTUAL-MOTOR ASPECTS OF POINTING

- Two-component model of pointing task [R.Woodworth ( 1899 ) ]
  - Initial phase : plan time
  - Error-corrective feedback phase: adjustment time

velocity  
time  
Plan time Adjustment time  
Peak velocity

Experiment to clarify the relationship between peak velocity and target distance

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## TARGET DISTANCE AND VELOCITY Experiment

- Apparatus
  - 20inch CRT
  - 6DOF position sensor (Fastrak)
  - Cube controller(side:5cm)
  - C-D ratio=1
- Task
  - Positioning of the cursor to the target cube
- Task condition
  - direction ( ) × distance
    - (-90, -45, 0, 45, 90 deg) × (5, 10, 20 cm)
- Participant
  - 6 males

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## TARGET DISTANCE AND VELOCITY Result

- Linear relationship between peak velocity and target distance
- The relationship dependence on movement angle

Peak velocity [cm/s]  
Distance [cm]  
Linear regression

Peak velocity [cm/s]  
Direction [deg]  
Legend: 5cm, 10cm, 20cm

Target distance can be predicted by using the amplitude of peak velocity

**Regression model**  
Target Distance =  $a \times$  Peak velocity +  $b$

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## THE DELPHIAN DESKTOP Simple Prediction Algorithm (1/2)

- Calibration for each user
  - Sampling of peak velocity and target distance in normal pointing task
  - Calibrate the prediction model by linear regression analysis of obtained data for 4 directions
    - (vertical, horizontal, diagonal x 2 directions)

Regression model

$$D = a \times V_p + b$$

$D$  : Target distance  
 $V_p$  : Peak velocity  
 $a, b$  : Individual constant

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## THE DELPHIAN DESKTOP

### Simple Prediction Algorithm (2/2)

- Prediction algorithm using the individual regression model

$D = a \times Vp + b$

**In Delphian Desktop**

5. The cursor jumps to the predicted point with brief animation

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## DEMO MOVIE

- Delphian Desktop
  - Application prototype (demonstrated last night)
    - Cursor jumps and snaps to the most probable icon
  - Experimental system (used for evaluation)
    - Cursor only jump, does not snaps

pictures

if snap shots of demonstration looks good, they may be inserted here

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## EVALUATION Setup (1/2)

- Hardware
  - 19 inch LCD ( 1280×1024 pixel ) [DELL]
  - Stereo speakers
  - Large mouse pad ( 408×306 mm ) [POWER SUPPORT]
  - Optical wheel mouse [Logitech]
- Software
  - Experimental program
    - Implemented in Visual C++ 6.0
  - OS: Windows XP Professional
    - C-D ratio = 0.5
    - No cursor acceleration

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## EVALUATION Setup (2/2)

- Participant's posture
  - Comfortable position
  - The participant's elbows height set to the same height as the desk

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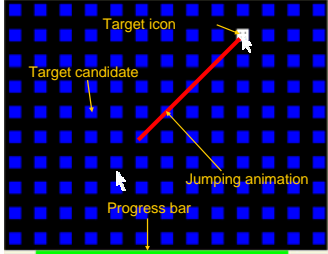
## EVALUATION Methodology (1/5)

- Method overview
  1. Calibration phase (Non-Prediction)
    - Participant moves cursor and clicks on current target
    - Tracking of cursor position and velocity
      - excluding missed clicks
      - Calculation of regression model
  2. Prediction phase
    - Participant moves cursor and clicks on current target
    - Prediction of target distance using the regression model
    - The cursor jumps to the predicted point
      - Cursor does not snap to the probable icon


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## EVALUATION Methodology (2/5)

- Display configuration





- Target display



Target  
(50 x 50 pixels)

- Click visual feedback

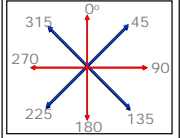
Success      Miss

Display resolution : 1280 x 1024

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## EVALUATION Methodology (3/5)

- Task condition
  - Target direction × Target distance
    - Vertical/horizontal task
      - (0, 90, 180, 270 deg) × (500, 600, 700, 800, 900 pixel)
    - Diagonal task
      - (45, 135, 225, 315 deg) × (707, 848, 989, 1131, 1272 pixel)
  - Overall : 40 task conditions



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## EVALUATION Methodology (4/5)

- Calibration phase, number of trials
  0. Practice session : 120
    - 3 minutes rest
  1. Session 1 : 320 ( 8 sets of tasks 8 x 40 )
    - 3 minutes rest
  2. Session 2 : 320 ( 8 sets of tasks 8 x 40 )
    - Overall : 640 x 2 phase = 1280 trials ( for an hour )
      - 5 minutes rest between phases
- Repeat three sessions for prediction phase
- Participants
  - 8 males (average age:23.0)
  - 8 females (average age: 25.8)

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## EVALUATION Methodology (5/5)

- Task presentation flow
  - Participants always start a new task from the previous target location

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## RESULTS(1/5) Movement time

- 2Way ANOVA
  - Prediction style (Prediction/Non-Prediction) × Target distance

Target distance [pixel]	Non-Prediction [ms]	Prediction [ms]
500	650	750
600	700	700
700	750	700
707	750	700
800	800	700
848	800	700
900	850	750
989	900	800
1131	950	850
1272	1000	900

- Significant interaction of prediction style x target distance
- Prediction was significantly faster than Non-Prediction style for 800pixel or longer distances

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## RESULTS(2/5) Movement time vs. Index of difficulty (ID)

- ID in extended 2D Fitts' law [J. Accot, S. Zhai, 2003]
 
$$ID = \log_2 \left( \sqrt{\left(\frac{D}{W}\right)^2 + \eta \left(\frac{D}{H}\right)^2} + 1 \right)$$
  - ID : Index of difficulty
  - D : Target distance
  - W : Target width
  - H : Target Height
  - η : Constant that depends on device (we used η = 1)

- Prediction was effective for 4.4 bits or higher ID (for over 800pixel target distances)

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## RESULTS(3/5) Gain

- The ratio of target distance and mouse movement distance
 
$$Gain = \frac{\text{Mouse movement Dist}}{\text{Target Dist}}$$

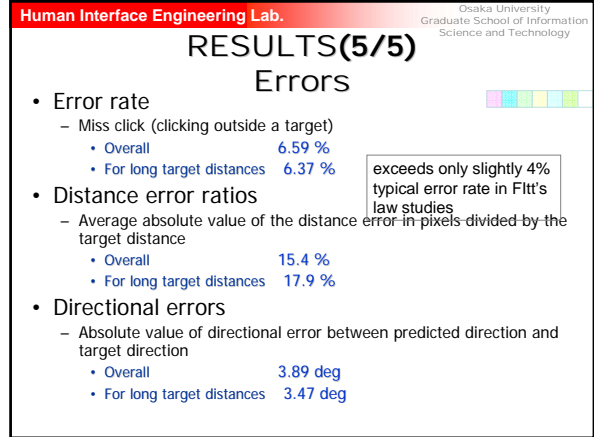
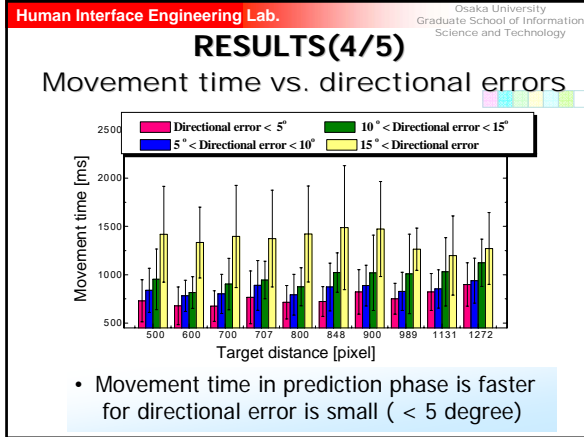
Target distance [pixel]	Gain
500	1.0
600	1.2
700	1.4
707	0.8
800	1.5
848	1.0
900	1.5
989	1.1
1131	1.2
1272	1.4

- Gain increased as target distance increase
- Mean of gain value was 1.21, exceeding 1
- (Diagonal tasks are shorter than vertical/horizontal tasks)

## Slide 21

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**ES1** Kazuki, please consider making the figure larger  
Ehud Sharlin, 10/18/2005



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## DISCUSSION

- For short target distance
  - Delphian Desktop predictions are not effective
    - ↳ Participants need the time to recognize the cursor jump
- Gain
  - Effective for long target distances
    - ↳ Longer jump decreases the effect of directional error.
- Combinations with related work
  - Delphian Desktop prediction algorithm can be adapted to "Expanding target", "Semantic pointing"
    - e.g.)
      - These can be applied after target prediction of the Delphian desktop

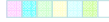
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## Future work

- Self calibration of prediction model (regression model)
- Extending Delphian Desktop to different environments
  - tabletop, large projection displays



## CONCLUSION



### Delphian Desktop

- Spatial prediction of user intentions in WIMP
- Kinesiology
- Algorithm
  - Prediction of target distance from the peak velocity
- Evaluation
  - Prediction is effective for long target distances in reducing pointing time and user's load