

Zooming User Interfaces: *Making Sense of Interaction Using a Model-Based Approach*

Parisa Eslambolchilar

Hamilton Institute, National University of Ireland,
Maynooth, Ireland



Hamilton Institute

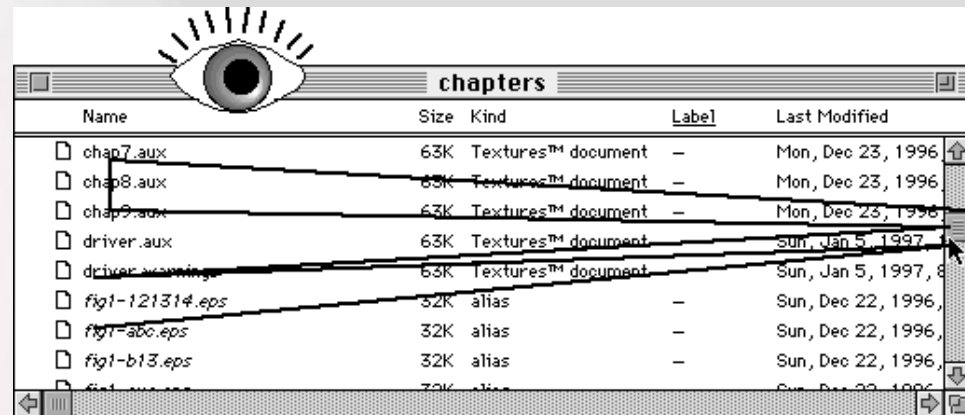
Motivation:

Zoom & Scrollbars in daily life!

We have a document or list and want to find something. What we do:

Scroll a bit, examining the document as we go until we find the required position in the text or list.

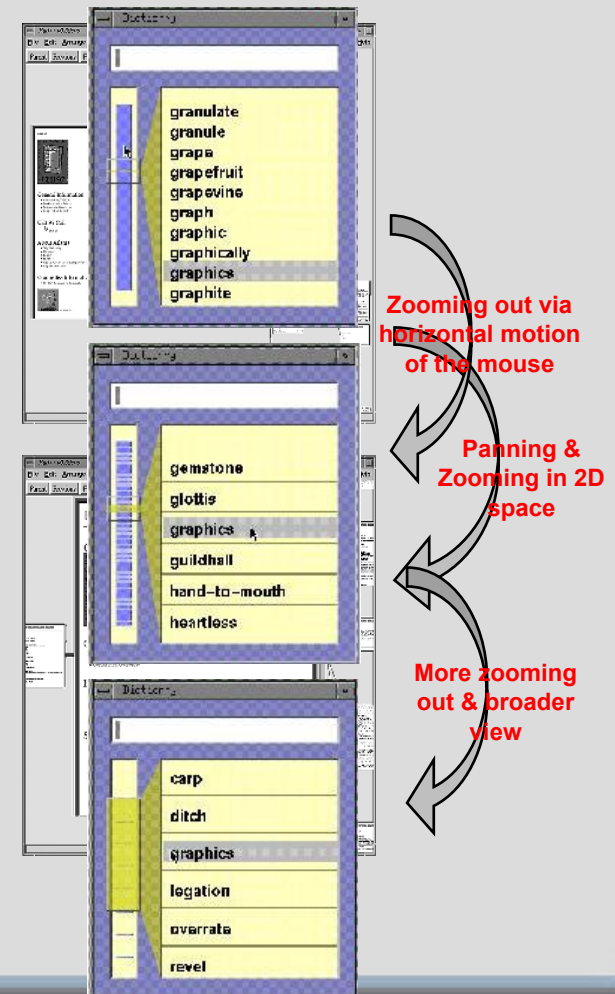
For reading the text (any European Language), eyes have to constantly scan from the scrollbar on the right (which we are controlling with a mouse and thus need to look at) to the start of the text on the left. To feel this in the extreme try resizing a window to make it very wide and short and then scroll to find something. Brewster et al. describe 'kangarooing'.



Previous Contributions

Scrolling Techniques

- **Lensbar** (Masui, 1998),
Controls rate of scroll with interactive filtering and semantic zooming, by providing explicit control of zooming via horizontal motion of the mouse cursor.
- **Pad & Pad++** (Bederson, 1998),
 - It provides continuous zooming as a central navigation tool by organizing objects in an infinite 2D information space,
 - The user accesses a target object using panning and zooming operations,
 - Difficult to coordinate both zooming and panning and the user can get lost in the infinite information space.



Information Visualization Techniques

- Fisheye views/menus (Furnas 1986, Bederson 1999)
- Perspective walls (Mackinlay, Robertson, and Card, 1991)
- Document lens (Robertson and Mackinlay, 1993)
- Hyperbolic trees (Lamping, Rao, and Pirolli, 1995)

(MARC) Twinbrook, White Flint, Grosvenor, Medical Center, Silver Spring (MARC), Forest Glen, Prince George's, Greenbelt (MARC) College Park-U of MD

Events, Knowledge, People, Categories, Places, Things, Qualities

18 - What immortal hand or eye
19 - Could frame thy fearful symmetry?
20 - In what distant deeps or skies
21 - Burnt the fire of thine eyes?
22 - On what wings dare he aspire?
23 - What the hand dare seize the fire
24 - Tiger, tiger, burning bright,
25 - In the forests of the night,
26 - What immortal hand or eye
27 - Could frame thy fearful symmetry?
28 - In what distant deeps or skies
29 - Burnt the fire of thine eyes?
30 - On what wings dare he aspire?
31 - What the hand dare seize the fire
32 - Tiger, tiger, burning bright,
33 - In the forests of the night,
34 - What immortal hand or eye
35 - Could frame thy fearful symmetry?

inxight

Speed dependent Automatic Zooming (SDAZ)

SDAZ **ouples** the user's rate of motion through an information space with the zoom level—the faster the user moves the 'higher' they fly above the work surface , providing a constant information flow across the screen (Igarashi & Hinckely, 2000).

- Scrolling a document without having to manually switch between zooming and scrolling
- No disorientation by fast visual flow,
- Results in a smooth curve in the space-scale diagram.



Figure 1. The Teletact II glove. |

Vibrotactile Stimuli
Vibrotactile stimuli are provided by commonly seen as an array of blunt

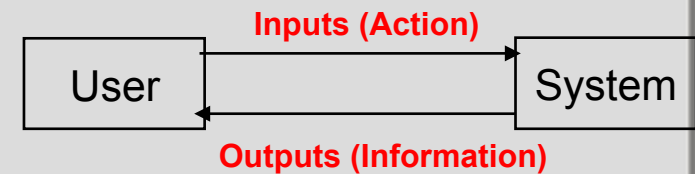
Purposeful Behaviour:

A theoretical Framework for Designing SDAZ

- In 1973 William Powers described a new approach to psychology based on the fact that behaviour is control.
- Behaviour **repeats**.
- Behaviour is control:
 - It is **consistent** results of **continuously** changing effects produced, **simultaneously**, by the organism and the environment.

How & When do apply control?

- We identify a variable that might be under control.
- Apply disturbances to the variable.
- Usually human is in closed-loop interaction with the system.
- Interaction takes place over a period of time so it is dynamic.



- In gesture recognition, haptic feedback, etc. the user is in **continuous**, **constant**, tightly **coupled** interaction with the computing system.

Model-Based Analysis: *A Systematic Approach to SDAZ*

Using accelerometer provides a direct intuitive mapping from acceleration in the real world to the acceleration in the interface, which also suggests a range of other affordances, important in multimodal feedback and we can choose to explicitly use these features to design the system to encourage interaction to fall into a comfortable, natural rhythm.

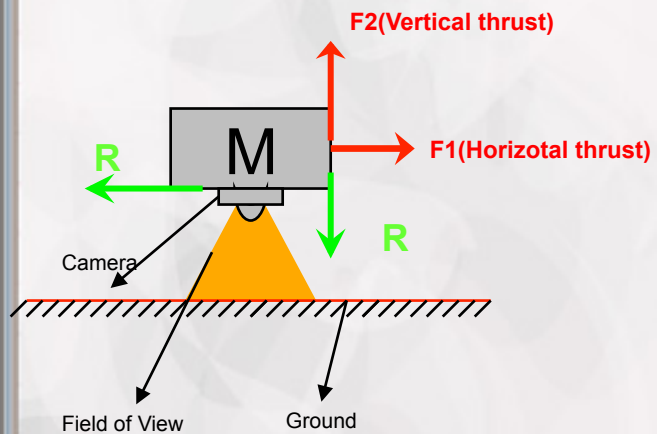
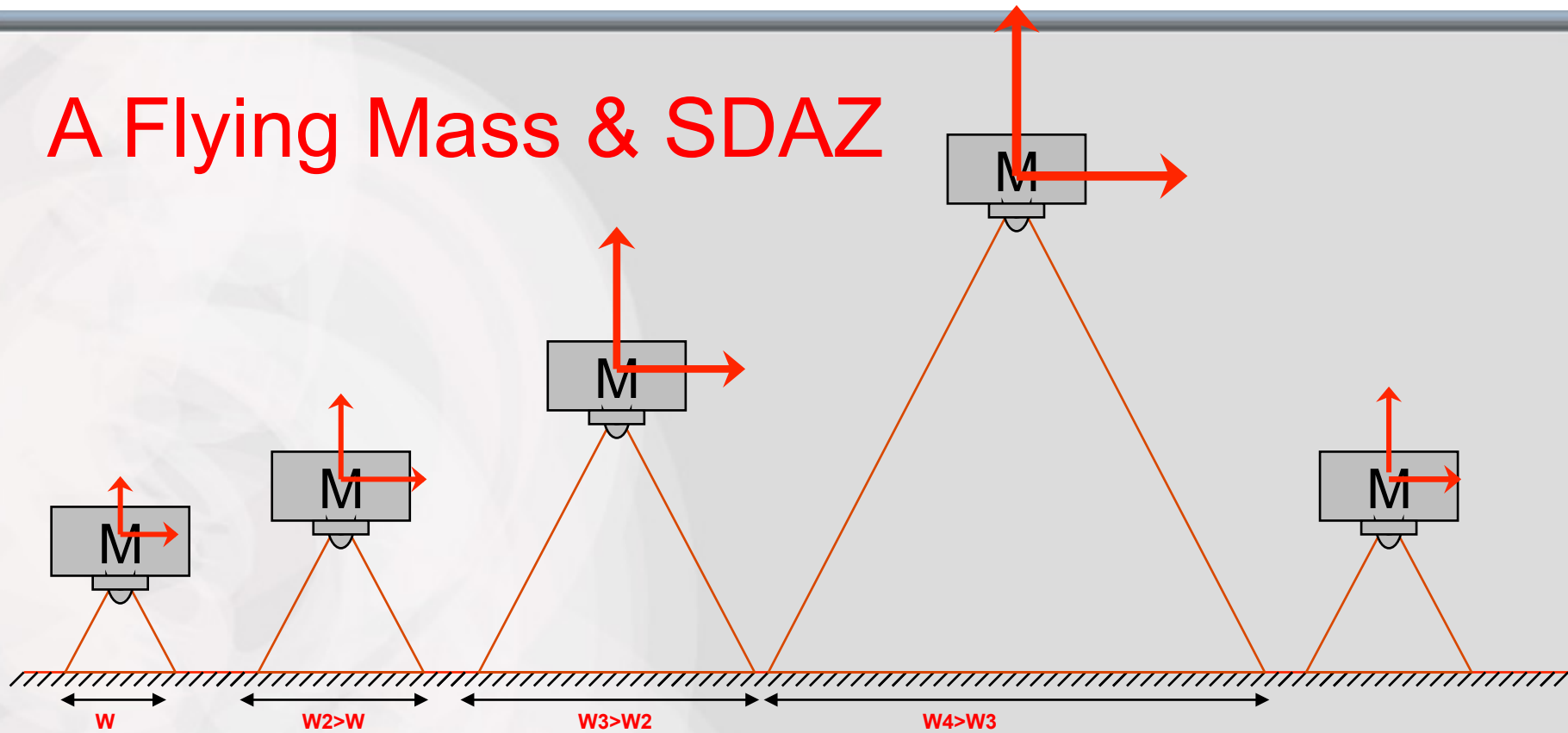
State space modeling

The generic form of state equations is

$$\begin{aligned}\dot{X} &= f(x) + g(u) \\ \dot{Y} &= h(x)\end{aligned}\tag{1}$$

where $f(x)$, $g(u)$ and $h(x)$ can be non-linear functions $X(t)$ is a state vector, $U(t)$ is an input vector and $Y(t)$ is an output vector.

A Flying Mass & SDAZ



R , Air Resistance, provides damping effects.

F_1 & F_2 are inputs to the system.

M , Mass

V , Velocity

Z , Zoom

\dot{Z} , Rate of change of zoom

Newton's second law of motion

Force = Mass * Acceleration

Cause of Change = Resistance to Change * Rate of Change

In Horizontal Direction:

$$M * \text{Acceleration} = F1 - R * V \quad \text{or} \quad \text{Acceleration} = F1/M - R * V/M \quad (2)$$

In Vertical Direction

$$M * Z\dot{=} = F2 - R * Z \quad \text{or} \quad Z\dot{=} = F2/M - R * Z/M \quad (3)$$

and if F2 is a function of F1 and Velocity,

$$F2 = a * F1 - b * V$$

so,

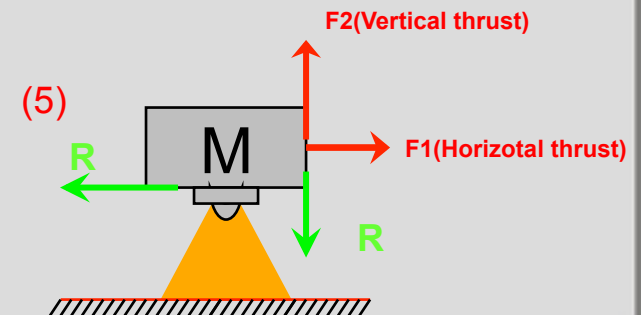
$$Z\dot{=} = a * F1/M - b * V/M - R * Z/M \quad (4)$$

If X is position then Velocity is the **first derivative** of the **position** and Acceleration is the **second derivative** of the **position**. So we can choose $x_1(t)$ for position, $x_2(t)$ for speed of scroll (V) and $x_3(t)$ for zoom (Z) as state variables,

$$\dot{x}_1(t) = V = x_2(t)$$

$$\dot{x}_2(t) = \dot{V} = \text{Acceleration} = \frac{-R}{M} x_2(t) + \frac{F1}{M}$$

$$\dot{x}_3(t) = \dot{Z} = \text{Rate of zoom changes} = \frac{-b}{M} x_2(t) + \frac{-R}{M} x_3(t) + \frac{a}{M} F1$$



Model-Based SDAZ on Mobile Devices: *State-space representation*

The more specific case of a linear system

$$\begin{aligned}\dot{x}(t) &= Ax(t) + Bu(t) \\ y &= Cx(t) + Du(t)\end{aligned}\tag{6}$$

where A is a square matrix called the *system matrix*, B is *input matrix*, C *output matrix* and D is a matrix which represents any direct connection between the input and output.

The standard matrix format of equations in (6) for SDAZ are:

$$\begin{aligned}\dot{x}_1(t) &= \dot{V} = x_2(t) \\ \dot{x}_2(t) &= \dot{V} = \frac{-R}{M}x_2(t) + \frac{F1}{M} \\ \dot{x}_3(t) &= \dot{Z} = \frac{-b}{M}x_2(t) + \frac{-R}{M}x_3(t) + \frac{a}{M}F1\end{aligned}\quad \longrightarrow \quad \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & \frac{-R}{M} & 0 \\ 0 & \frac{-b}{M} & \frac{-R}{M} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{k}{M} \\ \frac{a}{M} \end{bmatrix} u(t)$$

In all experiments $R=1$, $M=1$, $k=1$ and $b=0$.

A simple Example from Mechanics

Spring-Mass-Damper System



k : damping coefficient
 b : spring constant

External force

Equation of forced motion ----- >

$$m \frac{d^2 z}{dt^2} + k \frac{dz}{dt} + bz = F$$

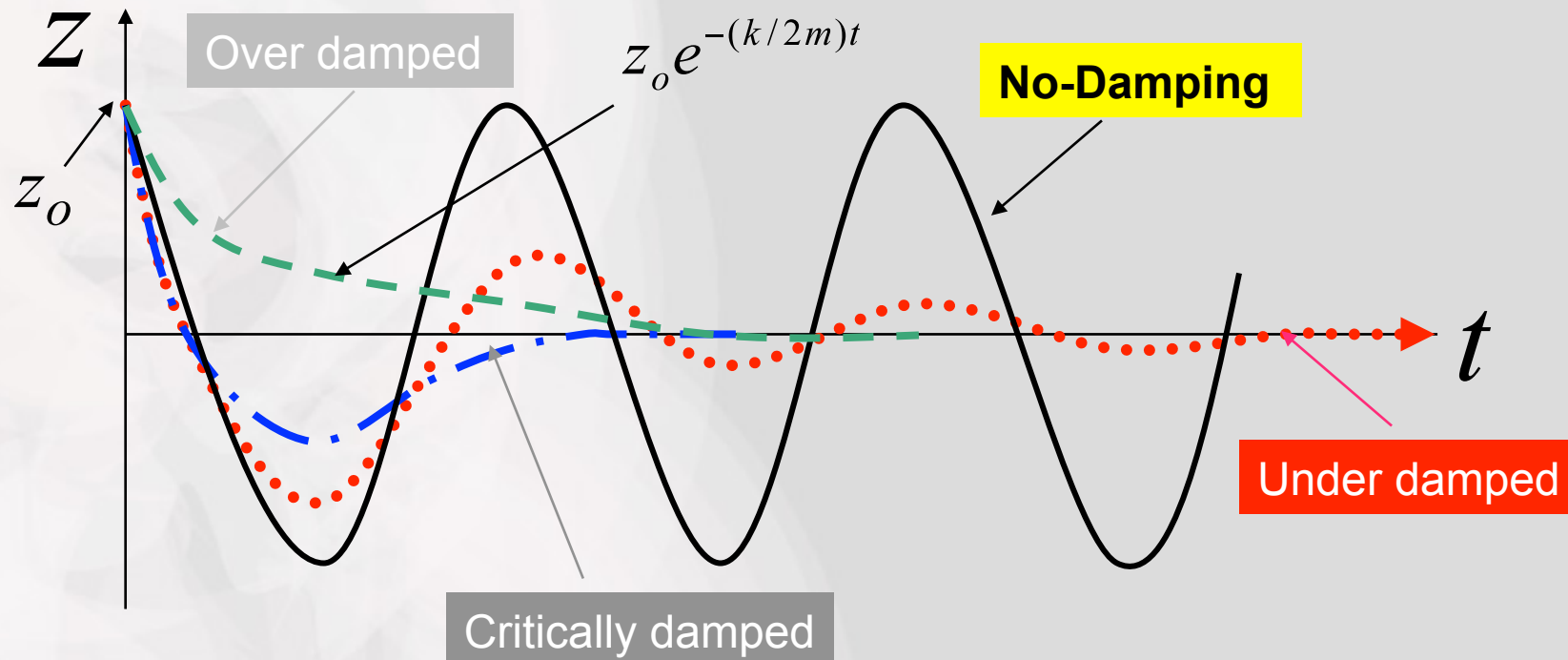
So we can introduce $x_1(t)$ for position (z),
 $x_2(t)$ for velocity:

$$\dot{x}_1(t) = \text{Velocity} = x_2(t) = \dot{z}(t)$$

$$\dot{x}_2(t) = \text{Acceleration} = \ddot{z}(t) = \frac{F}{M} - \frac{K}{M} x_2(t) - \frac{b}{M} x_1(t)$$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -\frac{b}{M} & -\frac{k}{M} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{1}{M} \end{bmatrix} u(t)$$

Spring-Mass-Damper System



- **Under Damped** : small damping, several oscillations
- **Critically Damped** : important level of damping, overshoot once
- **Over damped** : large damping, no oscillation

