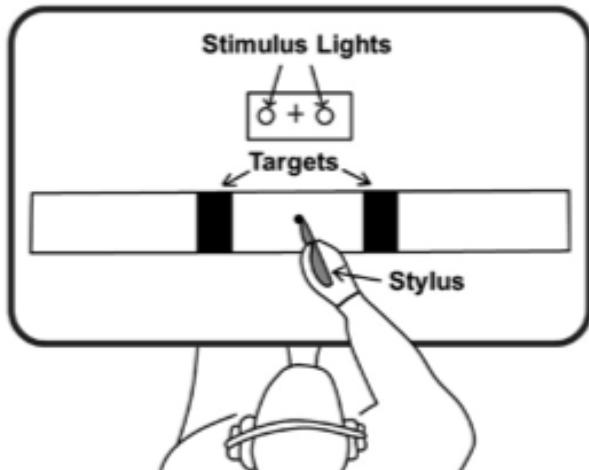


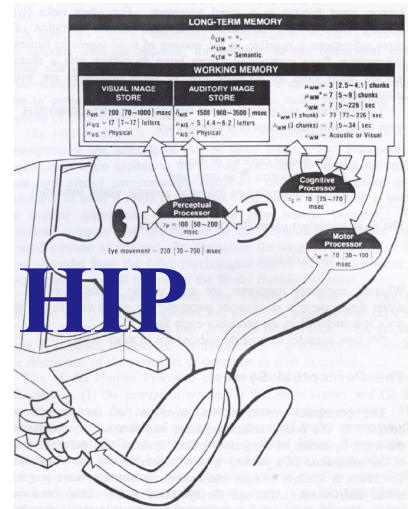
Syllabus

Part	Content	Week/Date	
Introduction	UI Revolution	1,2/Sep16, 23	HCI的价值取向、历史，研究方法
	Text-Entry; NUI project assignment	3/Sep30	
Human Ability	Ergonomics	4/Oct07	HCI以人的性能为优化目标，了解人的性能
	Perception; Cognition	5/Oct14	
	HIP Model; NUI project Proposal	6,7/Oct21, 28	
GUI	Fitts' Law study assignment	8/Nov04	GUI是主流界面模式，以交互效率为优化目标；实验理解优化模型
	GUI Design	9/Nov11	
	Fitts' Law Study/ NUI project Checkpoint1	10/Nov18	
	Hick's Law, KLM	11/Nov25	
	Evaluation Methods	12/Dec02	
NUI	AR, VR; Wearable; Smart Space / NUI project Checkpoint2	13/Dec09	NUI,实验实现自然交互技术
	VUI; Gesture; Hands free; Eyes-free NUI project report/demo	14,15/Dec16, 23	
	NUI discussion; NUI project report/demo	16/Dec30	

Explanation of Fitts' Law with HIP

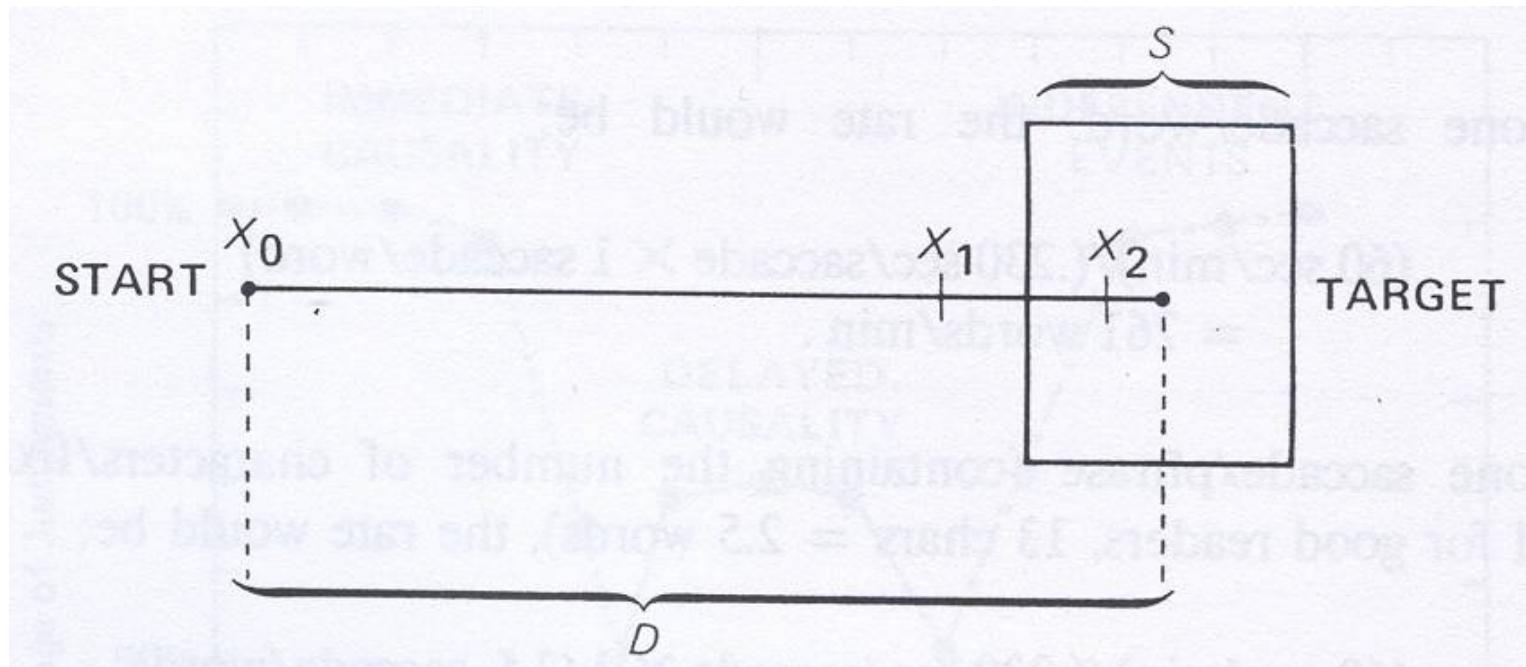


Fitts' Law



An explanation of Fitts' Law

$$T = a + b \log_2(D/S + 1)$$



X_i : Distance remaining after the i^{th} corrective move

An explanation of Fitts' Law

If the relative accuracy of movement is constant...

$$X_n = \varepsilon^n D, \quad (X_1 = \varepsilon X_0 = \varepsilon D), \quad \varepsilon = X_i / X_{i-1}$$

$$\varepsilon^n D <= \frac{1}{2} S$$

The hand stops moving when it is within the target area

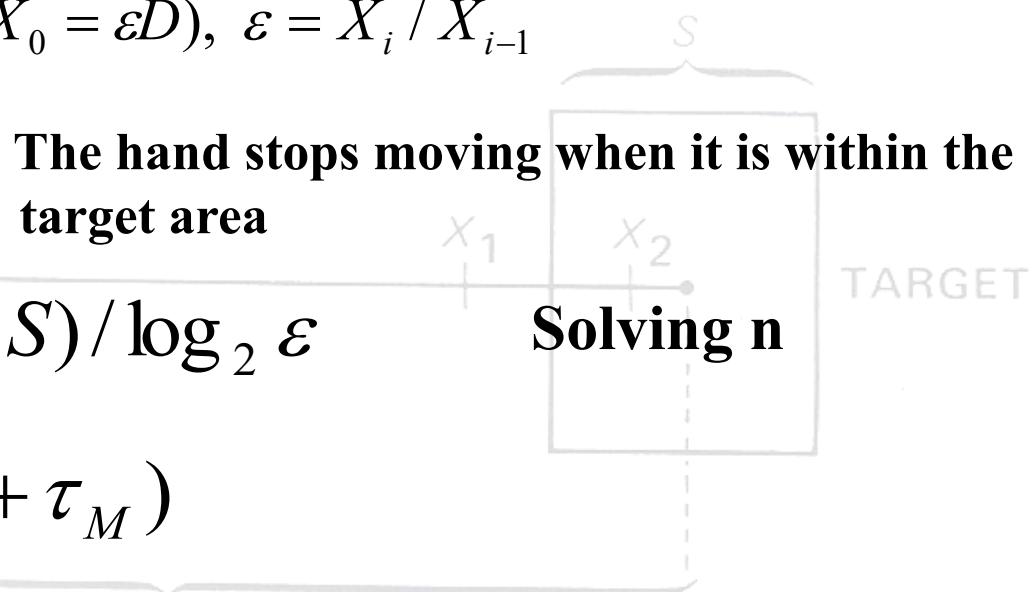
$$n = -\log_2 (2D/S) / \log_2 \varepsilon$$

$$T = n(\tau_P + \tau_C + \tau_M)$$

$$T = I_M \log_2 (2D/S), \quad I_M = -(\tau_P + \tau_C + \tau_M) / \log_2 \varepsilon$$

$$\varepsilon = 0.07$$

$$I_M = -240 / \log_2 0.07 = 63, [27 - 122]$$



Fitts' Law

- Fitts' Law describes the time taken to hit a screen target:

$$T = a + b \log_2(D/S + 1) \quad a=50, b=150$$

(The constants **a** and **b** are determined experimentally)

where:

a and **b** are empirically determined constants

T is movement time

D is Distance

S is Size of target



⇒ targets as large as possible
distances as small as possible

Fitts' Law

- $50 + 150 \log_2(80/50+1) = 256\text{ms}$

$$50 + 150 \log_2(80/5+1) = 663\text{ms}$$

$$T = a + b \log_2(D/S + 1)$$

(The constants a and b are determined by experiment)

where: a and b are empirically determined time
distance
of target

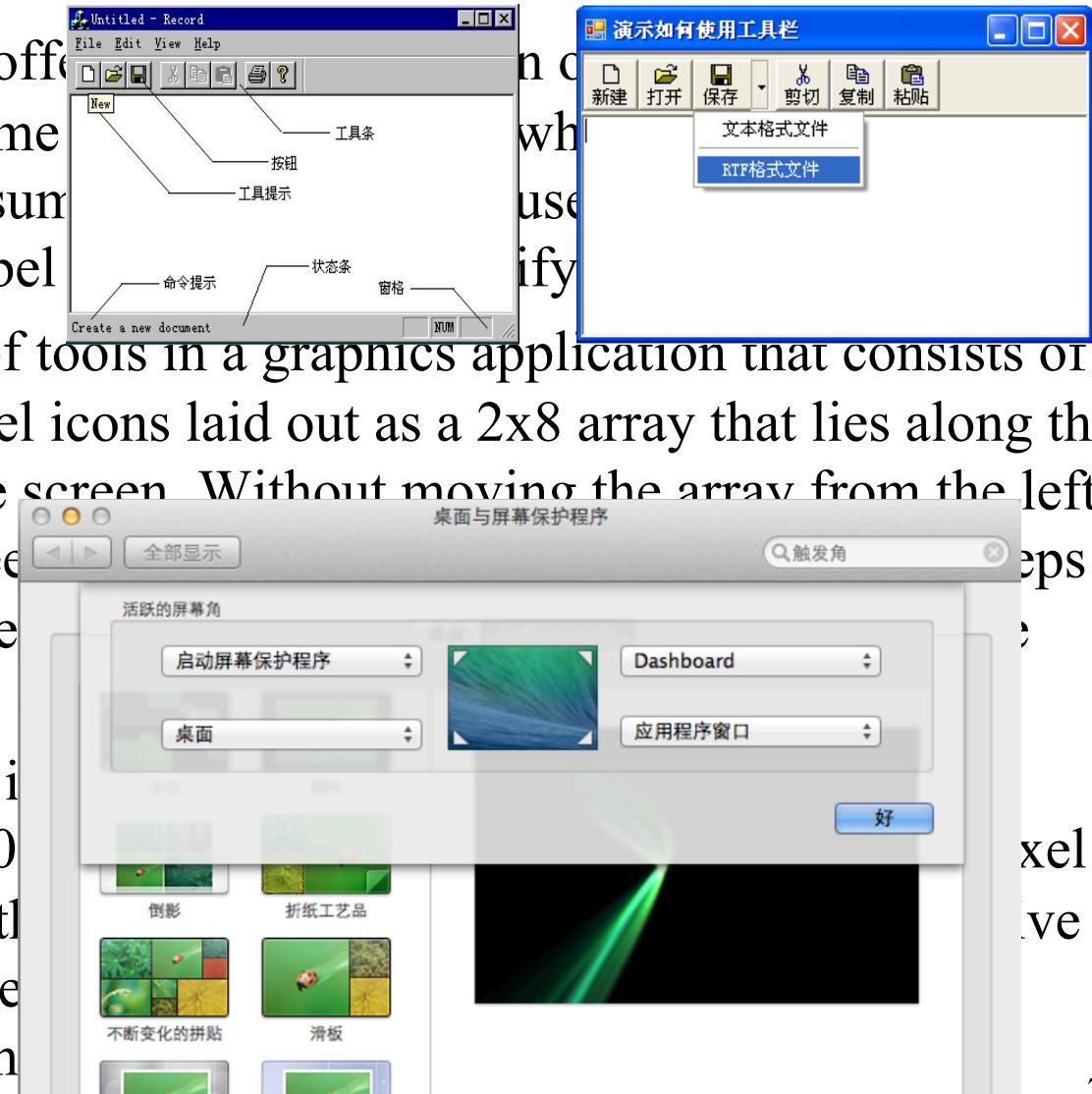
The screenshot shows a Microsoft PowerPoint window with the following details:

- Top Bar:** PowerPoint, File, Edit, View.
- Toolbar:** Standard icons for file operations like New, Open, Save, Print, etc.
- Home Tab:** Slides, Themes, Tables, etc.
- Slides Panel:** Shows a list of slides, with the current slide highlighted.
- Text on Slide:**
 - Slide number: 31
 - Title: Fitts' Law and Hick's Law
 - Equation: $50 + 150 \log_2(80/50+1) = 256\text{ms}$
 - Equation: $50 + 150 \log_2(80/5+1) = 663\text{ms}$
 - Note: (The constants a and b are empirically determined time)
- File Menu:** File, New, Open, Save, Print, etc.

⇒ targets as large as possible
distances as small as possible

Quiz 1-3

- Microsoft Toolbars often have labels below each tool. Name the three types of labels accessed faster. (Assume the application does not need the label)
- You have a palette of tools in a graphics application that consists of a matrix of 16x16-pixel icons laid out as a 2x8 array that lies along the left-hand edge of the screen. Without moving the array from the left-hand side of the screen, can you take to decrease the size of the tool?
- A right-handed user is in the center of a large, 160x160 pixel target on the screen that has 160 pixel locations on the perimeter. For extra credit, list them.



Quiz 4-6

- Microsoft offers a top, side or bottom hidden windows and be hidden or const



reasons why the method of triggering

center of a large, 1600 X 1200 screen. You will place a single-pixel target on the screen that the user must point to exactly. List the five pixel locations on the screen in order from fastest to slowest access.

le or bottom of the screen, enabling users to get to hidden windows and applications. This Taskbar may either be hidden or constantly displayed. Describe at what point Microsoft Taskbar is grossly inefficient.

five times faster than a typical Windows pull-down menu. For extra credit, suggest at least two reasons why Microsoft made such an apparently stupid

could make that bottleneck less of a problem?

ard, linear popup menus.

me for all items?

st of the keyboards by cutting their function keys in

on?

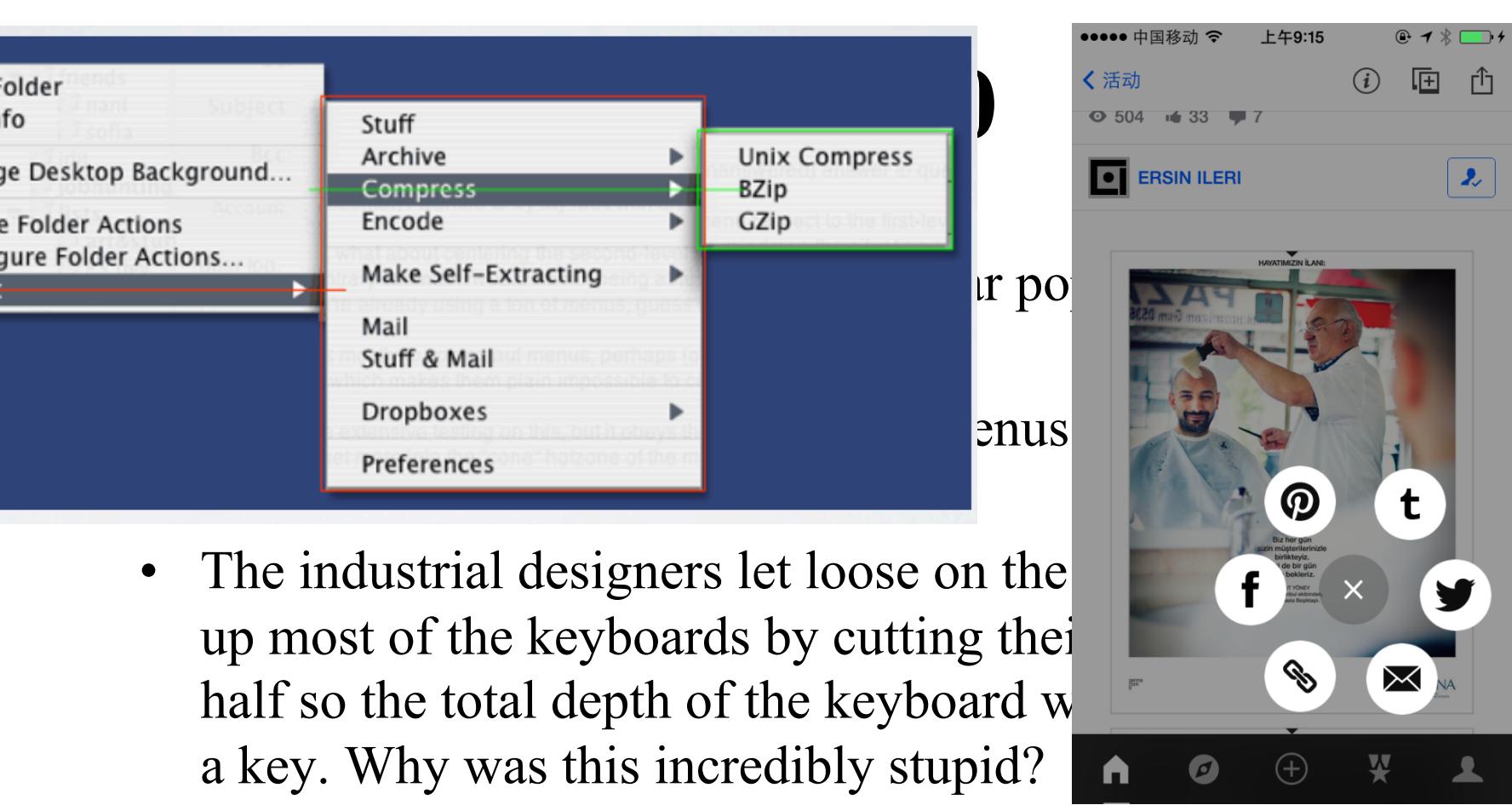
uble with the rest. You aren't alone, even though no one else had fewer power people at Apple cover these



Microsoft Word

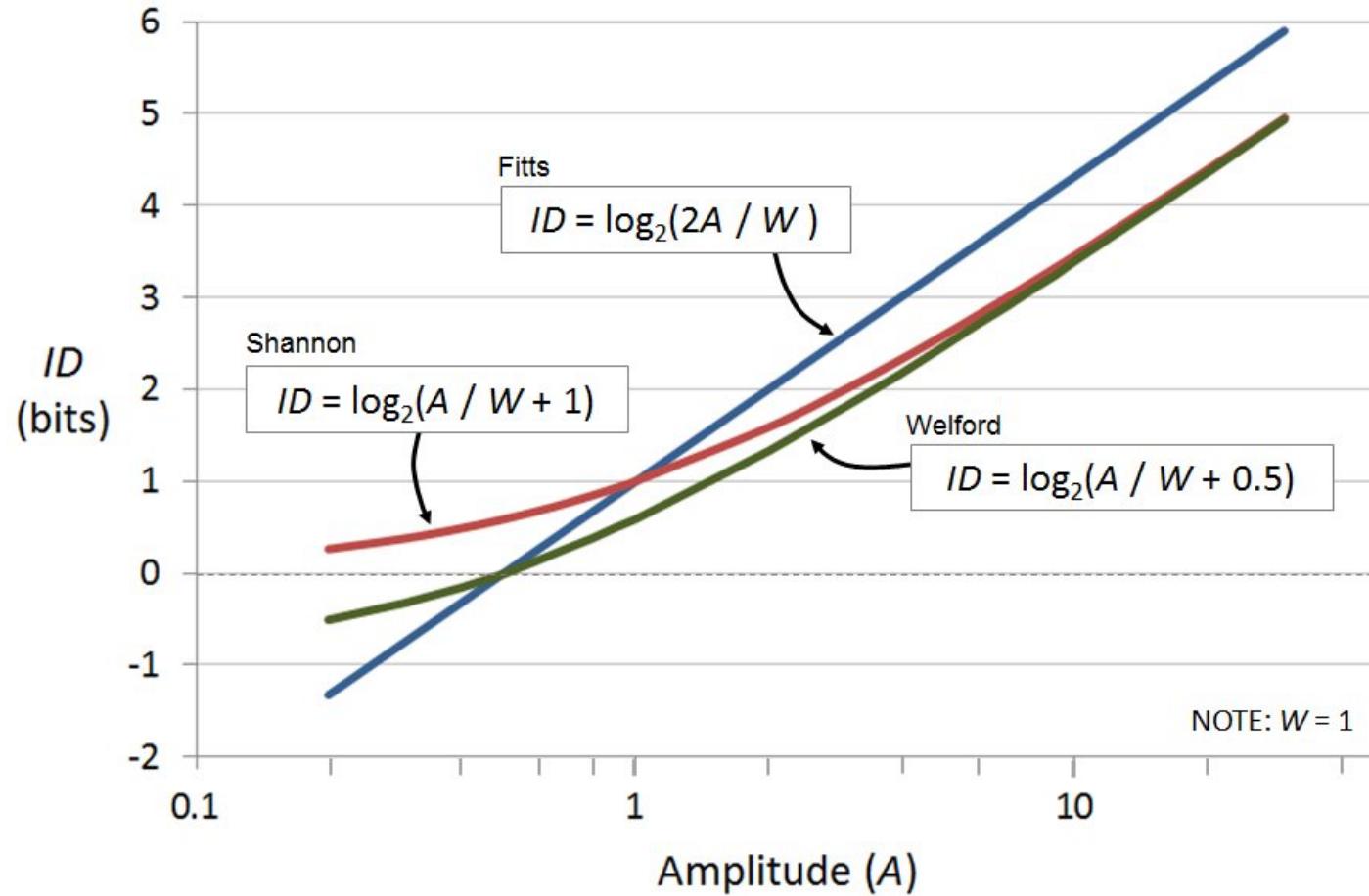


- What is the bottleneck in hierarchical menus and what techniques could make that bottleneck less of a problem?



- The industrial designers let loose on the up most of the keyboards by cutting them in half so the total depth of the keyboard was a key. Why was this incredibly stupid?
- What do the primary solutions to all these questions have in common?

Versions of Fitts' Law



Movement of a user's hand to a target

---In MacKenzie I S. *A note on the information-theoretic basis for Fitts' law*. Journal of Motor Behavior, 1989, 21(3): 323-330¹⁰

Fitts' Law (cont')

- Fitts' Law (error rate = 4%)

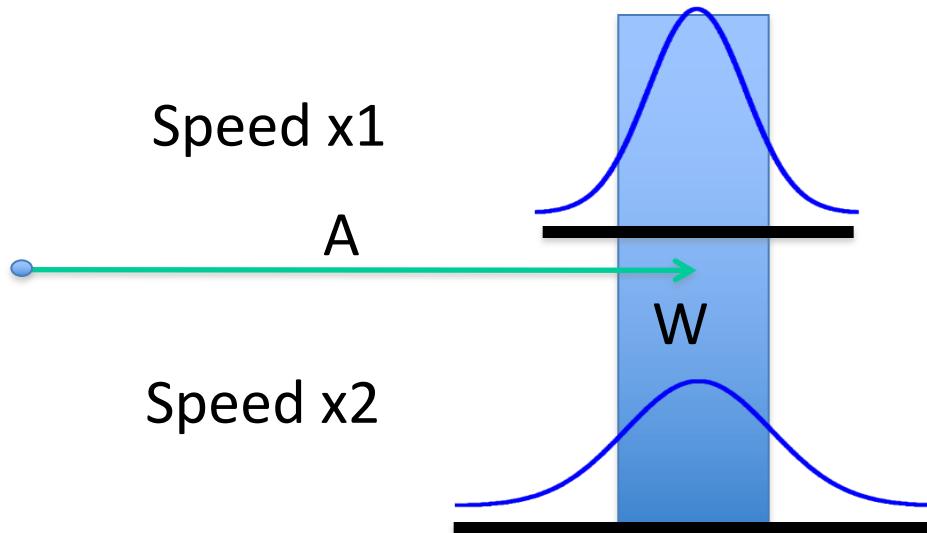
$$MT = a + b \times \log\left(\frac{A}{W} + 1\right)$$

- “Effective width” model (error rate \neq 4%)

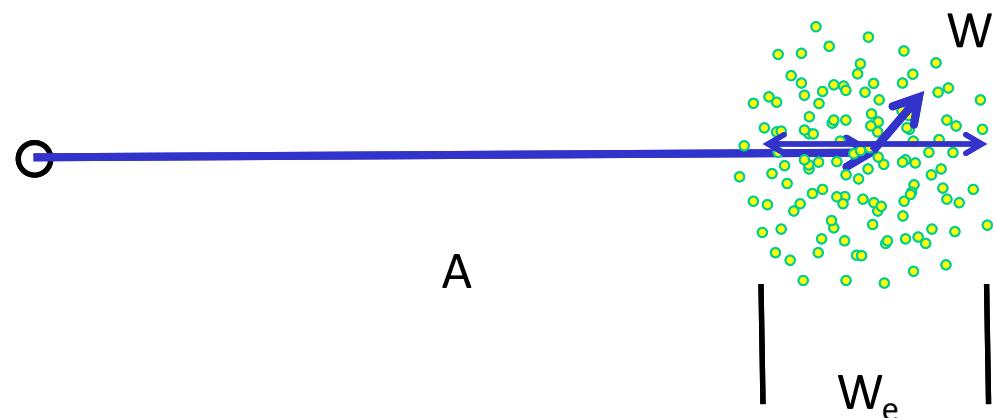
$$MT = a + b \times \log\left(\frac{A}{\sqrt{2\pi e}\sigma} + 1\right)$$

σ denotes the standard deviation of endpoint coordinates

“Effective Width” Model



Moving faster means
more inaccurate



Fitts' Law (cont')

- Fitts' Law (error rate = 4%)

$$MT = a + b \times \log\left(\frac{A}{W} + 1\right)$$

- “Effective width” model (error rate $\neq 4\%$)

$$MT = a + b \times \log\left(\frac{A}{\sqrt{2\pi e \sigma}} + 1\right)$$

σ denotes the standard deviation of endpoint coordinates

Fitts' Law for finger touch

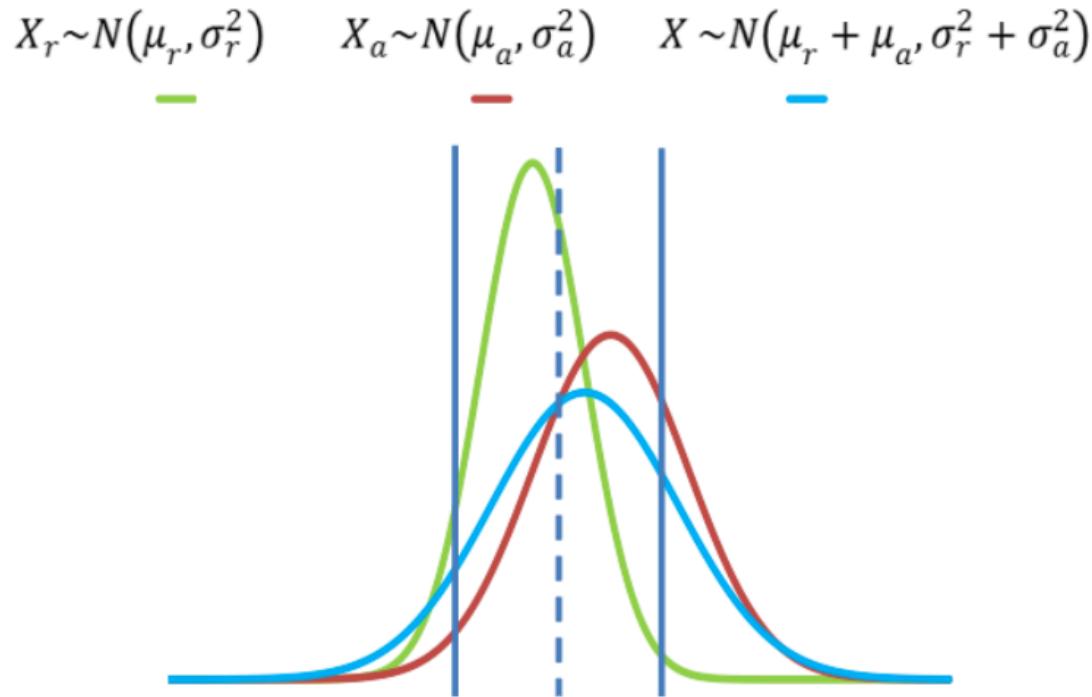


Figure 1. Dual distribution hypothesis in 1D Fitts' tasks. The two solid vertical lines represent the target, and the dashed line is the target center. The green, red and light blue curves show distributions of X_r , X_a , and X .

X_r : controlled by the speed accuracy tradeoff of the performer

X_a : reflects the absolute precision of a motor system that includes the implement

Fitts' Law for finger touch

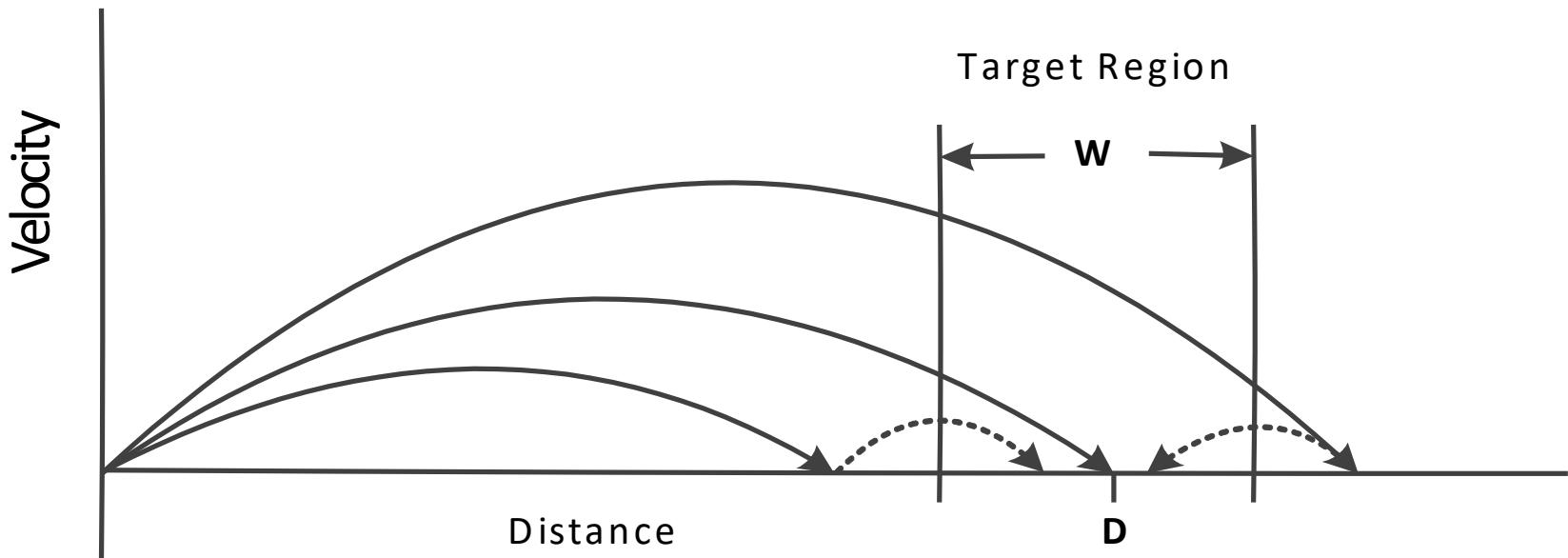
$$T = a + b \log_2 \left(\frac{A}{\sqrt{2\pi e(\sigma^2 - \sigma_a^2)}} + 1 \right)$$

σ_a : 0.94 mm for 1D task; 1.5 mm for 2D task

Bi, Xiaojun, Yang Li, and Shumin Zhai. "FFitts law: modeling finger touch with fitts' law." *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2013.

Stochastic optimized-submovement model

- A primary submovement and an optional secondary one.



Each submovement is a temporally constraint movement without online calibration

$$W_e = k \times \frac{A}{MT}^{16}$$

Temporally constraint movement

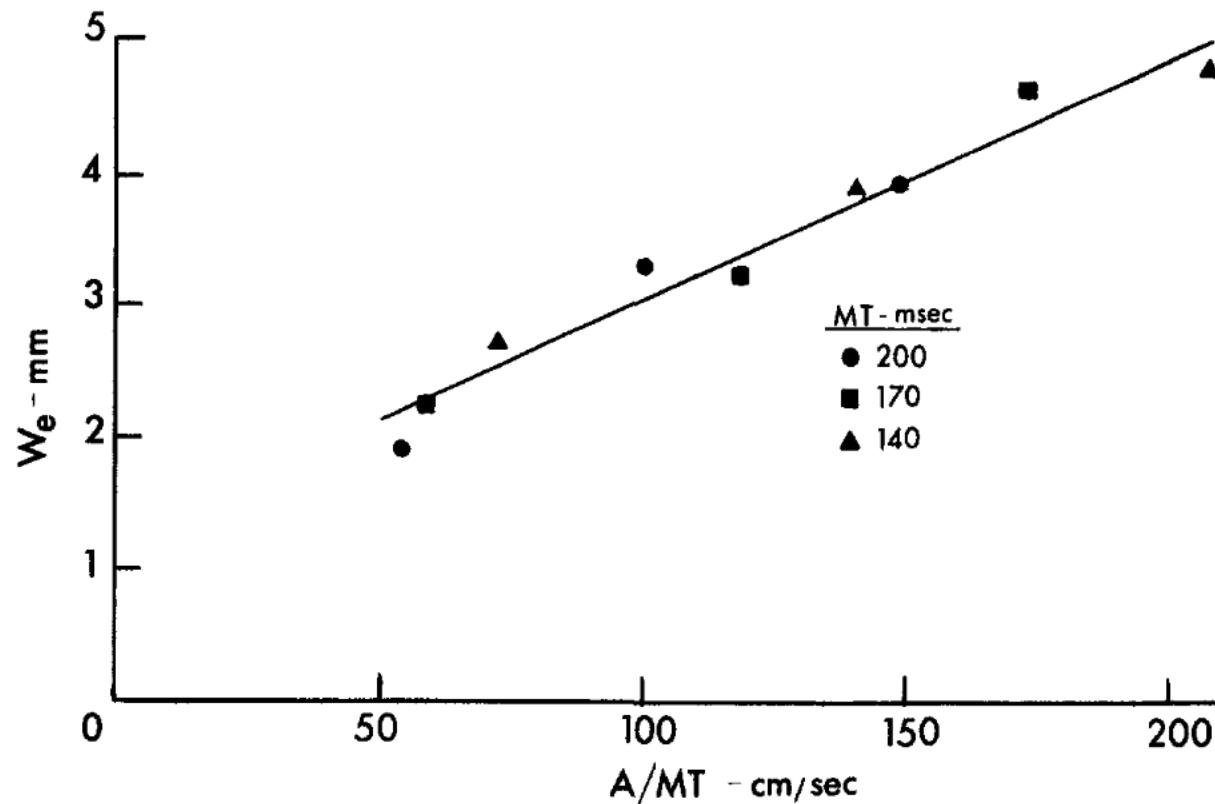
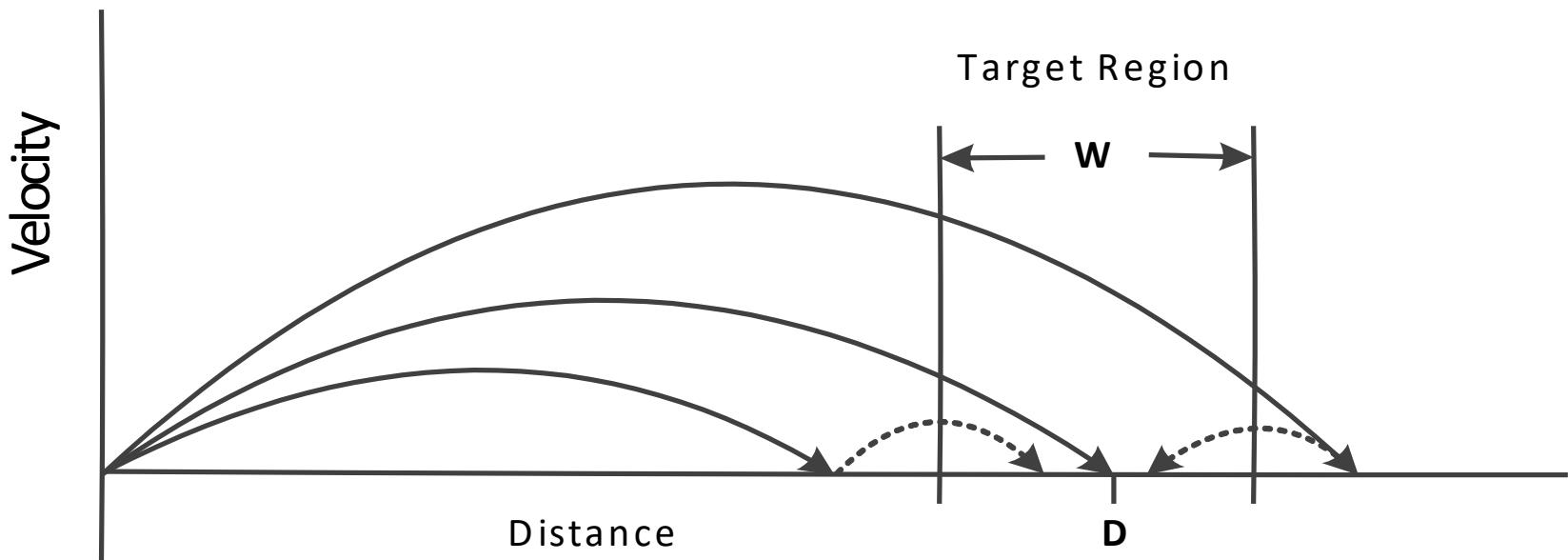


Figure 11. Effective target width (W_e) measured perpendicular to the direction of movement (direction error) as a function of the average velocity (A/MT).

Schmidt, Richard A., et al. "Motor-output variability: a theory for the accuracy of rapid motor acts." Psychological review 86.5 (1979): 415.

Movement control as an optimization problem



$$T = \min_s \left\{ \frac{A/W - 1/2}{s} + \mathbf{E}_{|\Delta| > W/2} \left(\frac{|\Delta|}{W} \right) \right\}$$

- **Chap 1 Design Principles (for GUI)**
- **Chap 2 Evaluation Methods**
- **Chap 3 GUI Optimization**

3.1 GUI Essential Factors

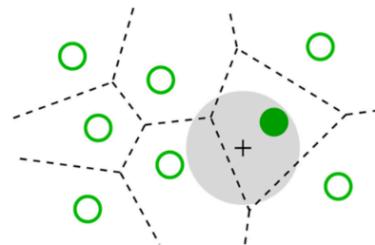
3.2 GUI Efficiency Models

3.1 GUI Essential Factors

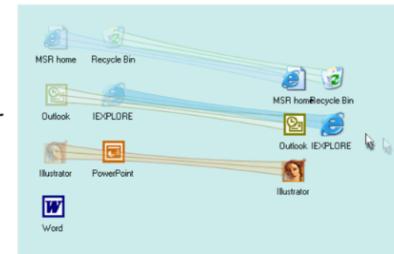
- **Pointing Device**
 - (human movement to cursor)
 - **Pointer**
 - (Surface)
 - **Widget Layout**
-
- ```
graph LR; A[Pointing Device
(human movement to cursor)] --- B[Relative Pointing]; A --- C[Pointer
(Surface)]; C --- D[Absolute Pointing]; B --- E[Mouse/touchpad...]; B --- F[Eye/hand movement]; B --- G[Body gesture]; D --- H[Laser pointer]; D --- I[Pen]; D --- J[Finger touch];
```

# 3.1 GUI Essential Factors

- Pointing Device
- Pointer / cursor
- Widget Layout



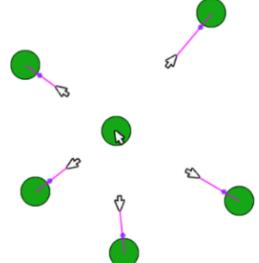
(a) Bubbe Cursor



(b) Drag and Pop

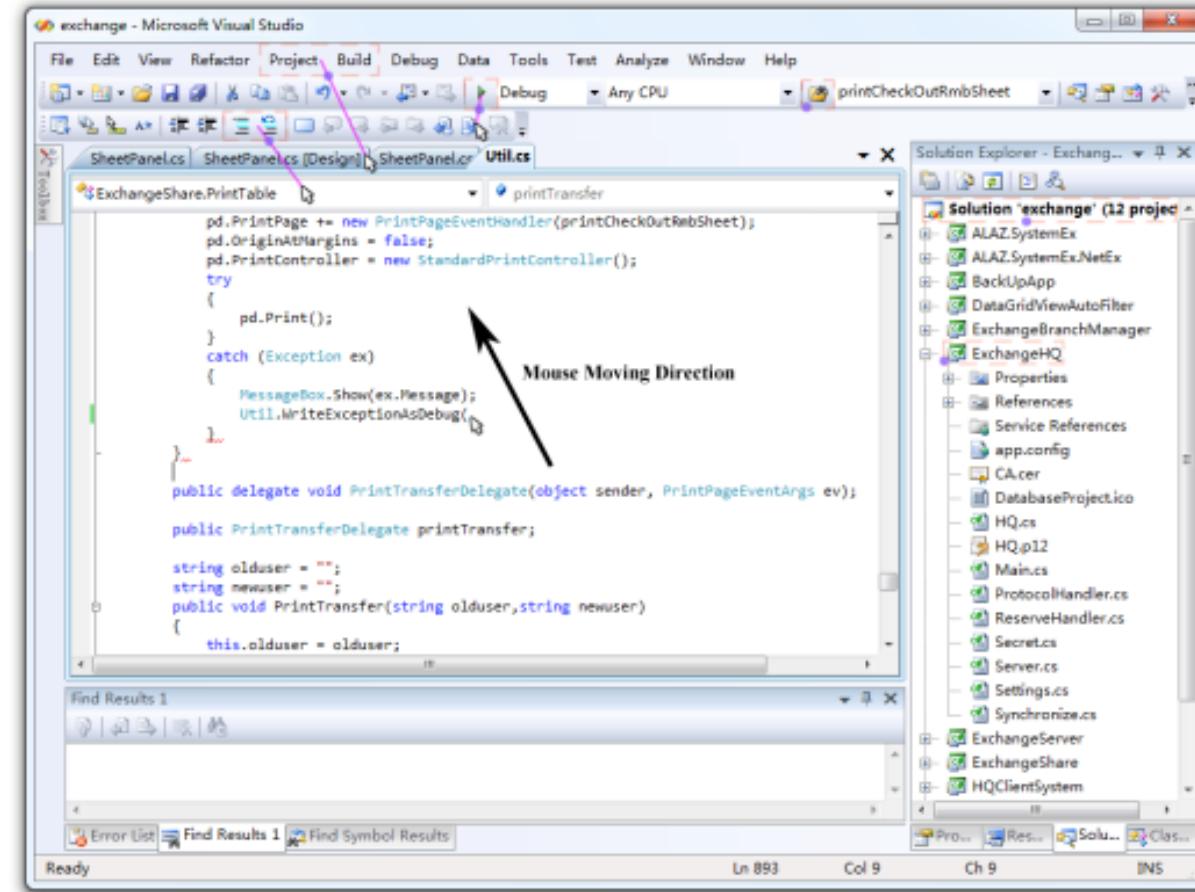
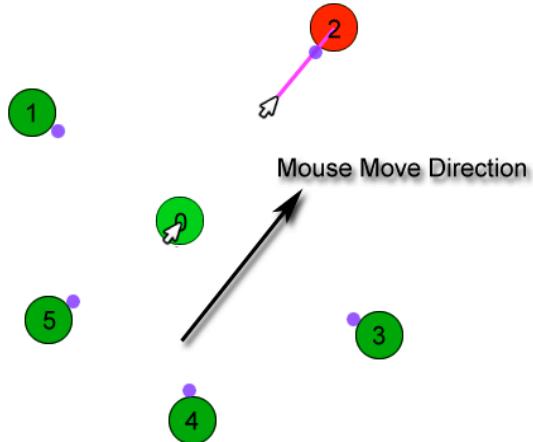


(c) Semantic Pointing



(d) Satellite Cursor

- Motor Space (control space, physical movement) vs. Visual Space (Display Space)
- Target-agnostic: Control/Display Ratio
- Target-aware: Bubble Cursor, Satellite Cursor (decrease D), Area Cursor (increase S), Semantic pointing (both)



Yu C, Shi YC.etc. The Satellite Cursor: Achieving MAGIC Pointing without Gaze Tracking using Multiple Cursors. *UIST'10*, 163-172

## 3.1 GUI Essential Factors

- Pointing Device
- Pointer
- Widget Layout

**Desktop: WMIP**(Windows, Menu, Icon, Pointing)

**Mobile: PWIG**(Page, Widget, Icon, Gesture)

# Chap 3 GUI Optimization

## 3.1 GUI essential factors

## 3.2 GUI Efficiency Models

***GOMS-LKM***

**Fitts' and Hick**

**Scroll model:**

$$MT = a + b * \log_2 n + l$$

$$MT = a + b * n$$

Cockburn A, Gutwin C. A predictive model of human performance with scrolling and hierarchical lists. *HCI* 2008, 24(3): 273--314.

## Layout Appropriateness

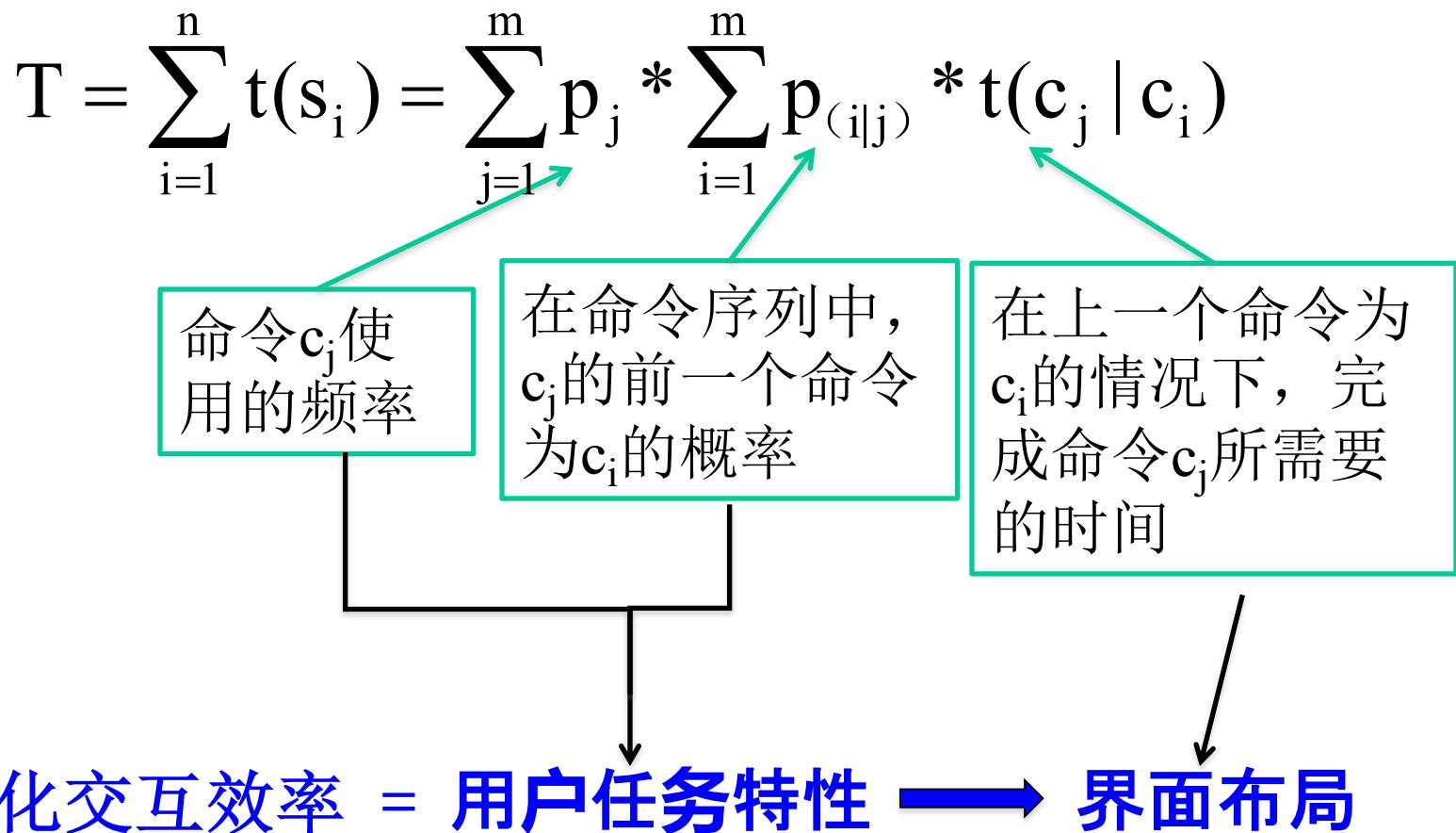
$$LA = (\text{cost of the LA-optimal layout}) / (\text{cost of the proposed layout})$$

Sears A. Layout appropriateness: A metric for evaluating user interface widget layout. *Software Engineering*, 1993, 19(7):707–719.

# GUI Efficiency Evaluation Model

- User input sequence  $S = s_1, s_2, s_3, \dots, s_n$ ,  
command set  $= \{c_1, c_2, c_3, \dots, c_m\}$
- CUI:  $T = \sum_{i=1}^n t(s_i) = \sum_{j=1}^m p_j * t(c_j)$
- GUI:  $T = \sum_{i=1}^n t(s_i) = \sum_{j=1}^m p_j * \sum_{i=1}^m p_{(i|j)} * t(c_j | c_i)$

# GUI Efficiency Evaluation Model



# GUI Efficiency Evaluation Model

$$T = \sum_{i=1}^n t(s_i) = \sum_{j=1}^m p_j * \sum_{i=1}^m p_{(i|j)} * t(c_j | c_i)$$

用户任务属性包括：

- 命令 $c_j$ 使用的频率： 概率
- 在命令序列中， $c_j$ 的前一个命令为 $c_i$ 的概率：  
一阶概率转移矩阵

完成任务（命令序列）所需要的最小信息量

命令序列最优吗？

命令序列的重编码（压缩）

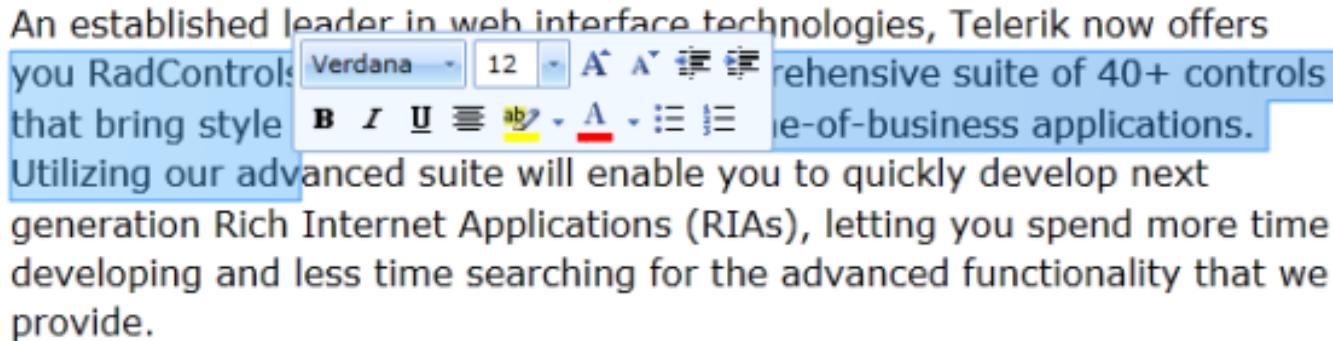
- 基本思想：将以高概率出现的特定序列压缩为短序列

# GUI Efficiency Evaluation Model

$$T = \sum_{i=1}^n t(s_i) = \sum_{j=1}^m p_j * \sum_{i=1}^m p_{(i|j)} * t(c_j | c_i)$$

## 界面布局优化

- $t(c_j | c_i)$  由Fitts Law决定，即：指点距离和目标面积
- 根据 $P(j|i)$ 计算图形元素的布局、句柄位置和大小
- 已有案例：
  - Word浮动栏
- 风险：不断
- 策略：效率提升和学习成本的折衷



# GUI Efficiency Evaluation Model

$$T = \sum_{i=1}^n t(s_i) = \sum_{j=1}^m p_j * \sum_{i=1}^m p_{(i|j)} * t(c_j | c_i)$$

Frequency of

Frequency of the

Time to complete  $c_j$

its previous  $c_i$

An established leader in web interface technologies, Telerik now offers you RadControls that bring style to your applications. Utilizing our advanced suite will enable you to quickly develop next generation Rich Internet Applications (RIAs), letting you spend more time developing and less time searching for the advanced functionality that we provide.

Optimized UI = Feature of Task  $\xrightarrow{\downarrow}$  UI Layout