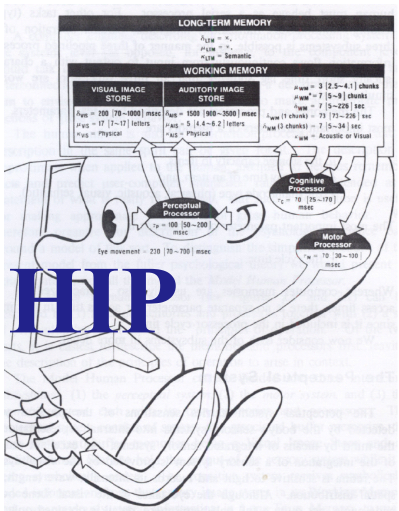
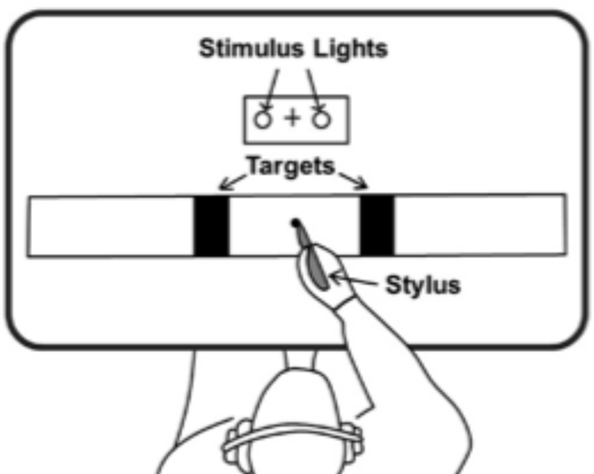
Syllabus

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	



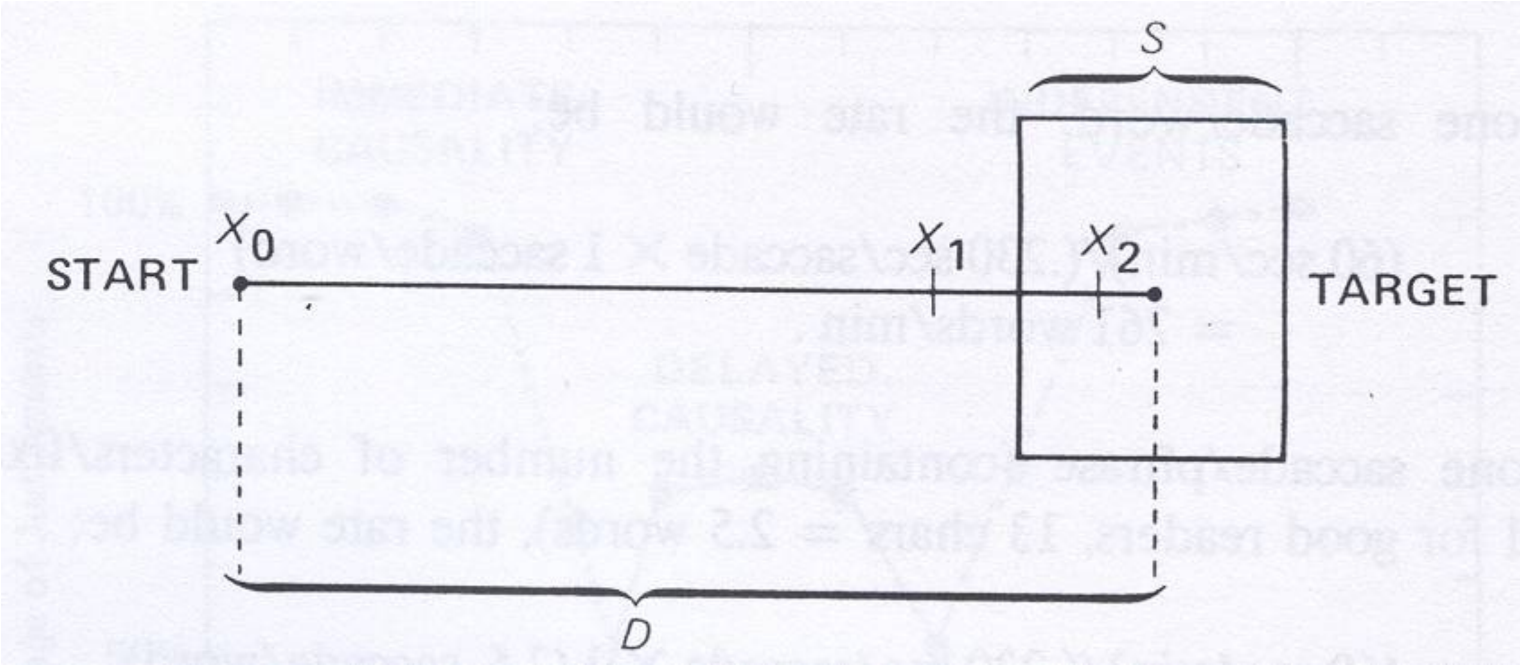
Explanation of Fitts' Law with HIP



Fitts' Law

An explanation of Fitts' Law

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



X_i : Distance remaining after the **i**$^{\mathbf{th}}$ corrective move

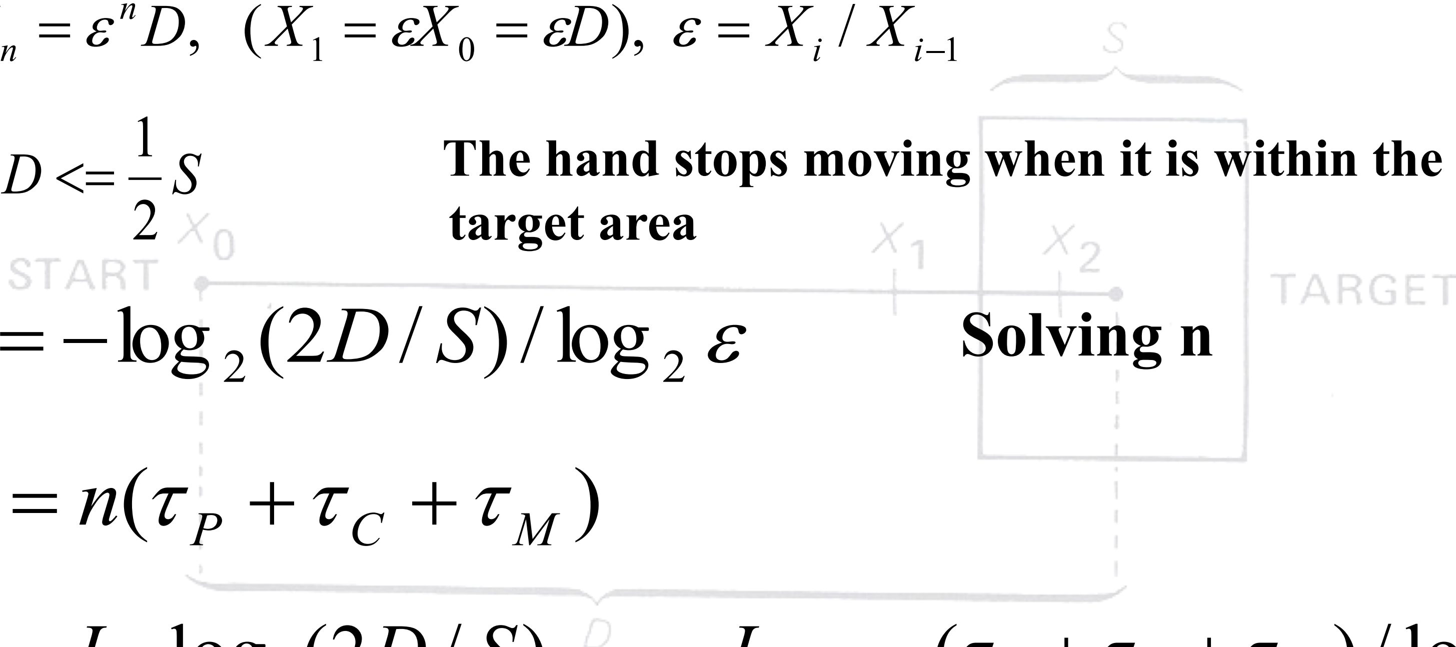
An explanation of Fitts' Law

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



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

Solving n

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

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

$$\varepsilon = 0.07$$

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

Fitts' Law

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

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

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

- $50+150\log_2(80/50+1)=256ms$
  $50+150\log_2(80/5+1) \; =663ms$ ake

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

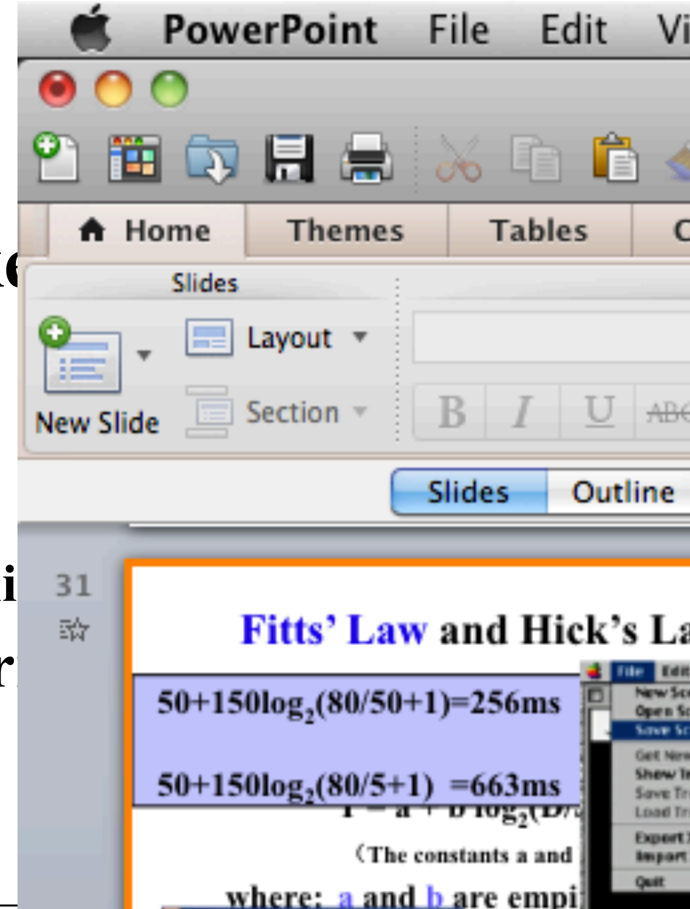
（The constants a and b are determi

where: a and b are empirically deter

ment time

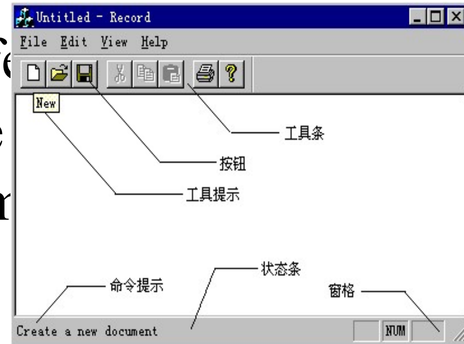
nce

f target



⇒ targets as large as possible
distances as small as possible

Quiz 1-3



- Microsoft Toolbars offe … n c
below each tool. Name … wh
accessed faster. (Assum … use
does not need the label … ify
- 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 scree … eps
can you take to decre … e
tool?
- A right-handed user i …
center of a large, 160 … xel
target on the screen t … ive
pixel locations on the
extra credit, list them

Quiz 4-6

- Microsoft offers a
top, side or bottom
hidden windows a
be hidden or const
reasons why the method of triggering
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as
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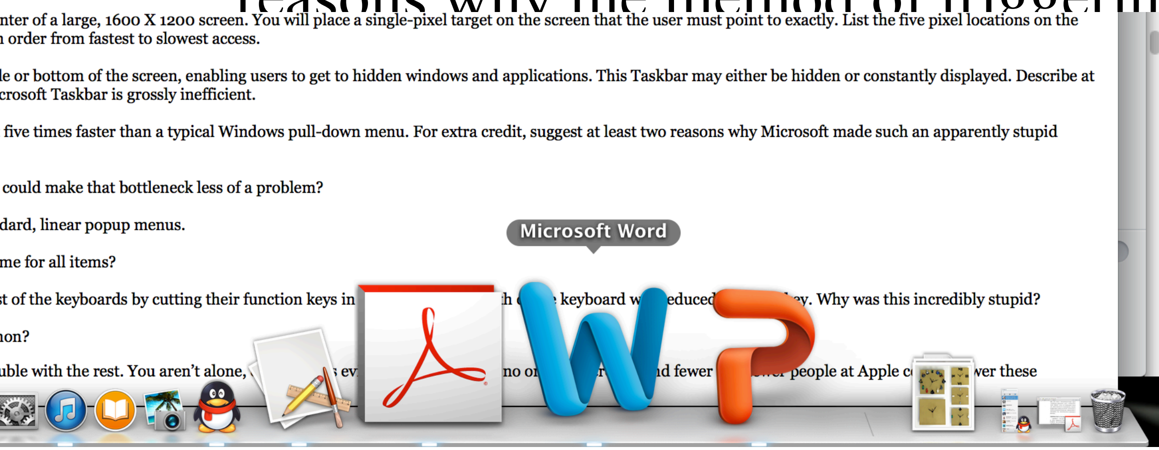
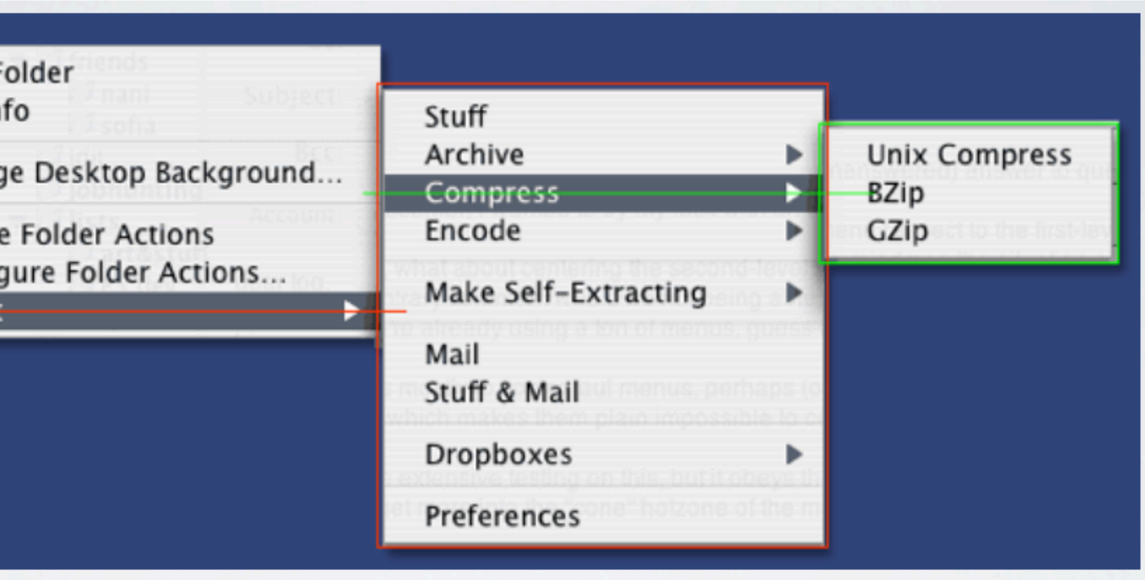
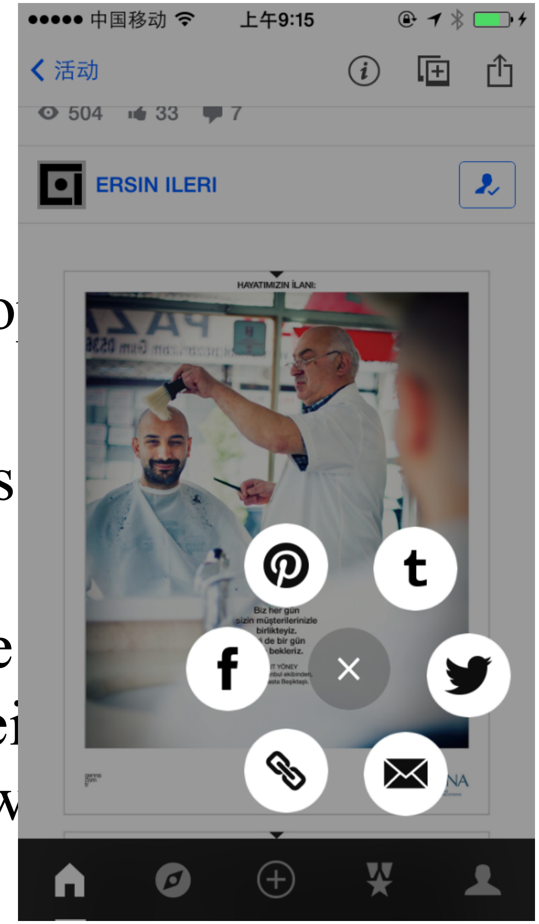


- What is the bottleneck in hierarchical menus and what techniques could make that bottleneck less of a problem?



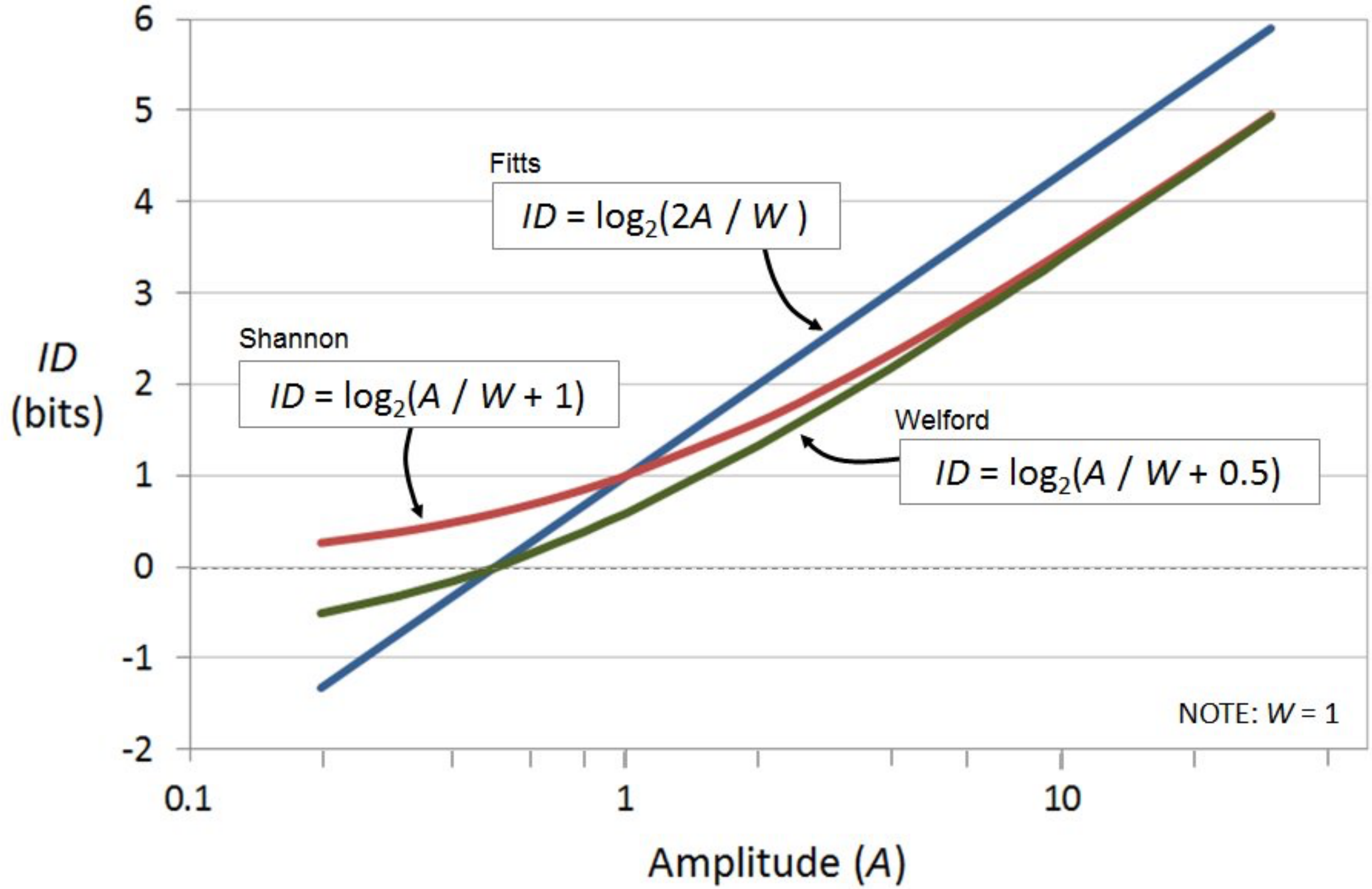


ur po

enus

- The industrial designers let loose on the up most of the keyboards by cutting thei half so the total depth of the keyboard w 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): 323-330

Fitts' Law (cont')

- Fitts' Law（error rate = 4%）

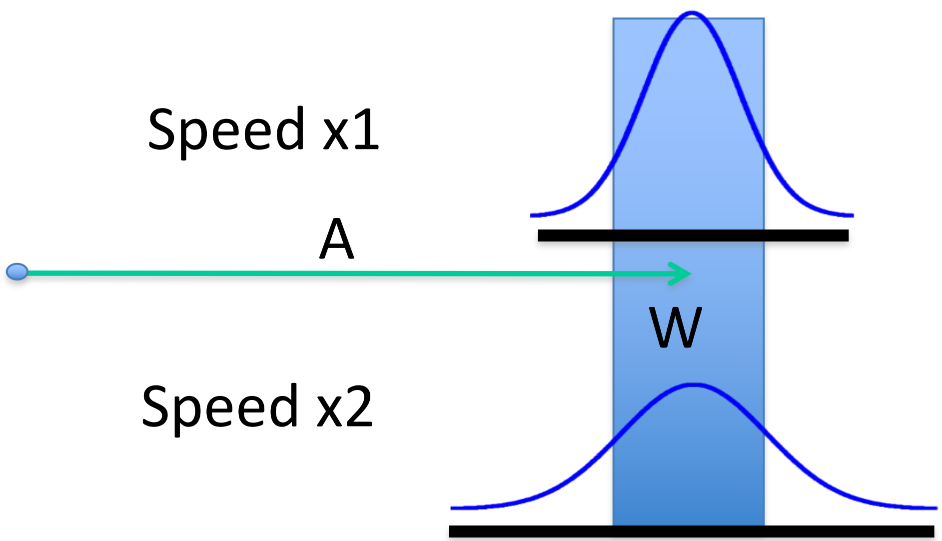
$$MT = a + b \times \log(\frac{A}{W} + 1)$$

- "Effective width" model（error rate ≠ 4%）

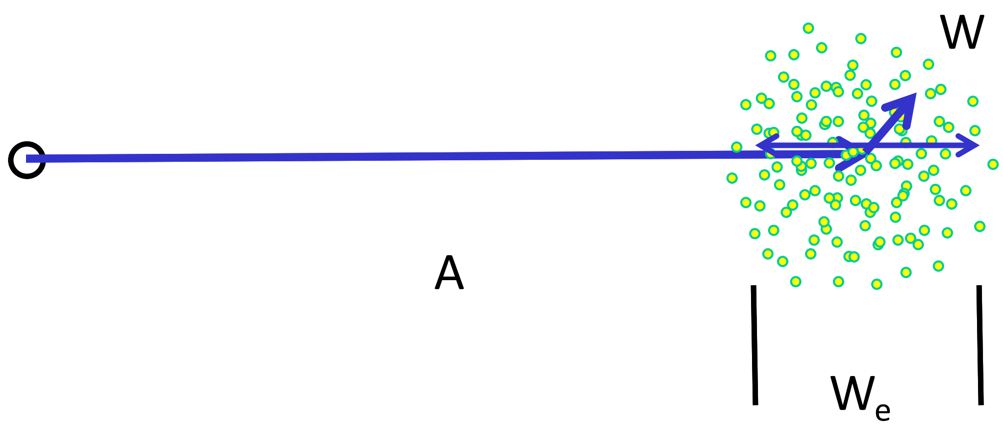
$$MT = a + b \times \log(\frac{A}{\sqrt{2\pi e}\sigma} + 1)$$

σ denotes the standard deviation of endpoint coordinates

“Effective Width” Model



Moving faster means more inaccurate



Fitts' Law (cont')

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Fitts' Law for finger touch

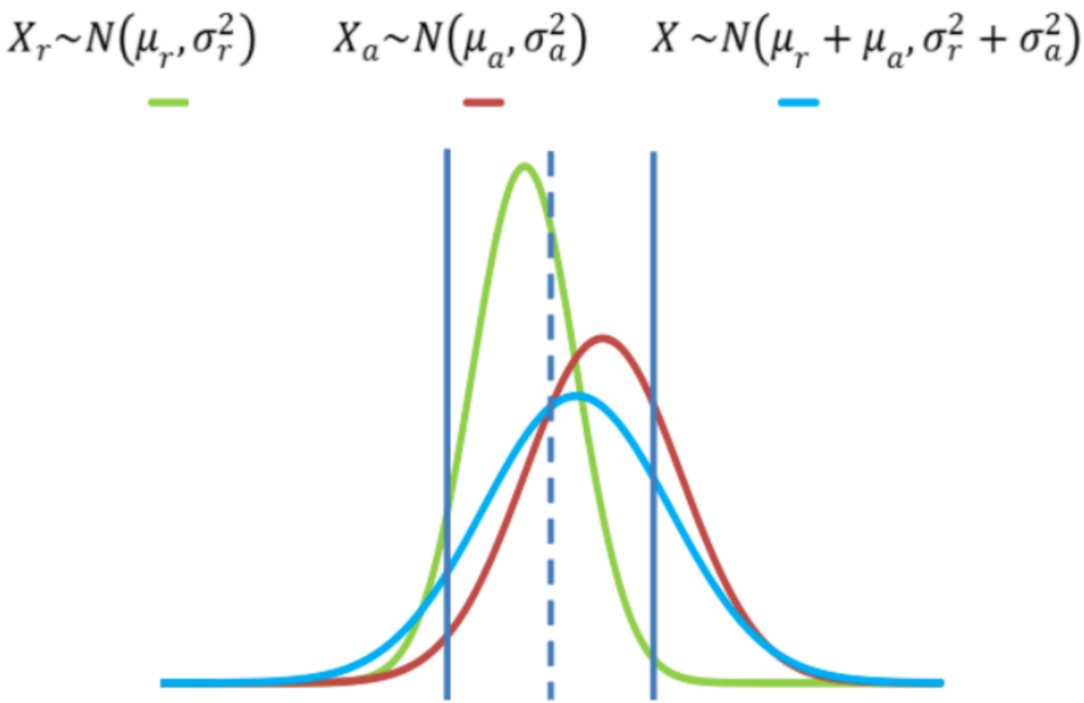


Figure 1. Dual distribution hypothesis in 1D Fitts' tasks. The two solid vertical lines represent the target, and the dashed line is the target center. The green, red and light blue curves show distributions of X_r, X_a, and X.

Xr: controlled by the speed accuracy tradeoff of the performer

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

Fitts' Law for finger touch

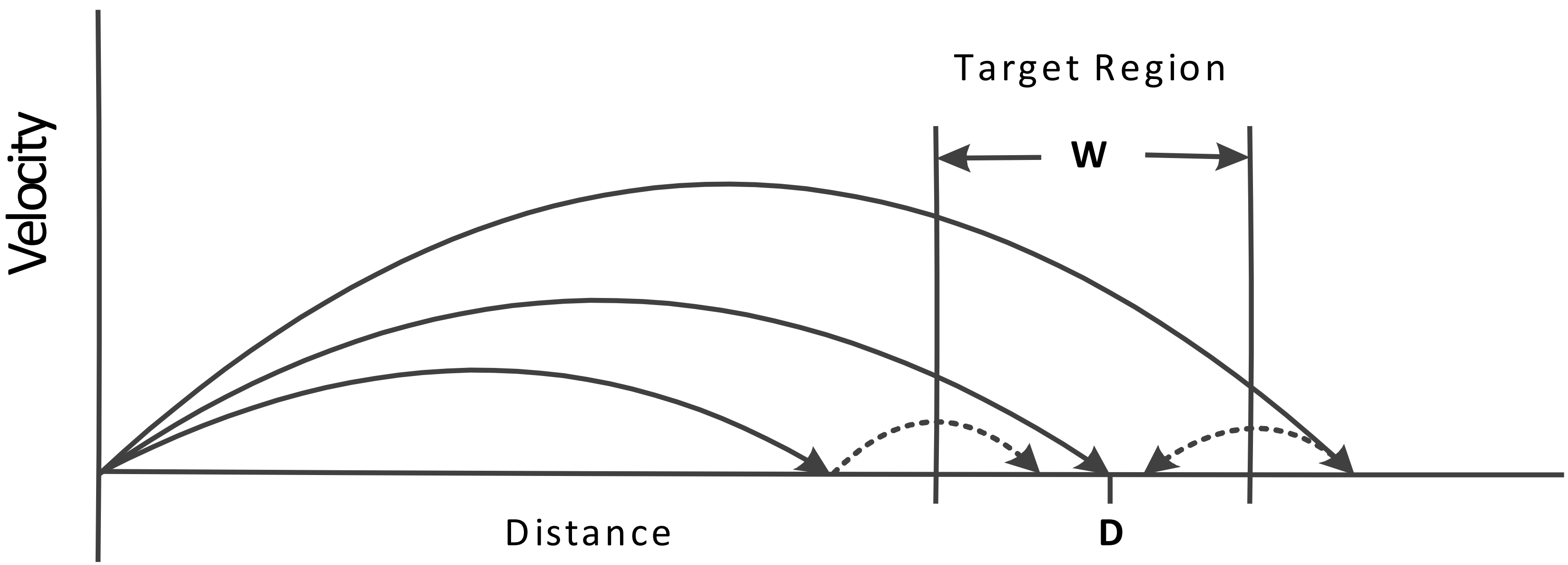
$$T = a + b\log_2\left(\frac{A}{\sqrt{2\pi e(\sigma^2 - \sigma_a^2)}} + 1\right)$$

$\boldsymbol{\sigma_a}$: 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

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

Temporally constraint movement

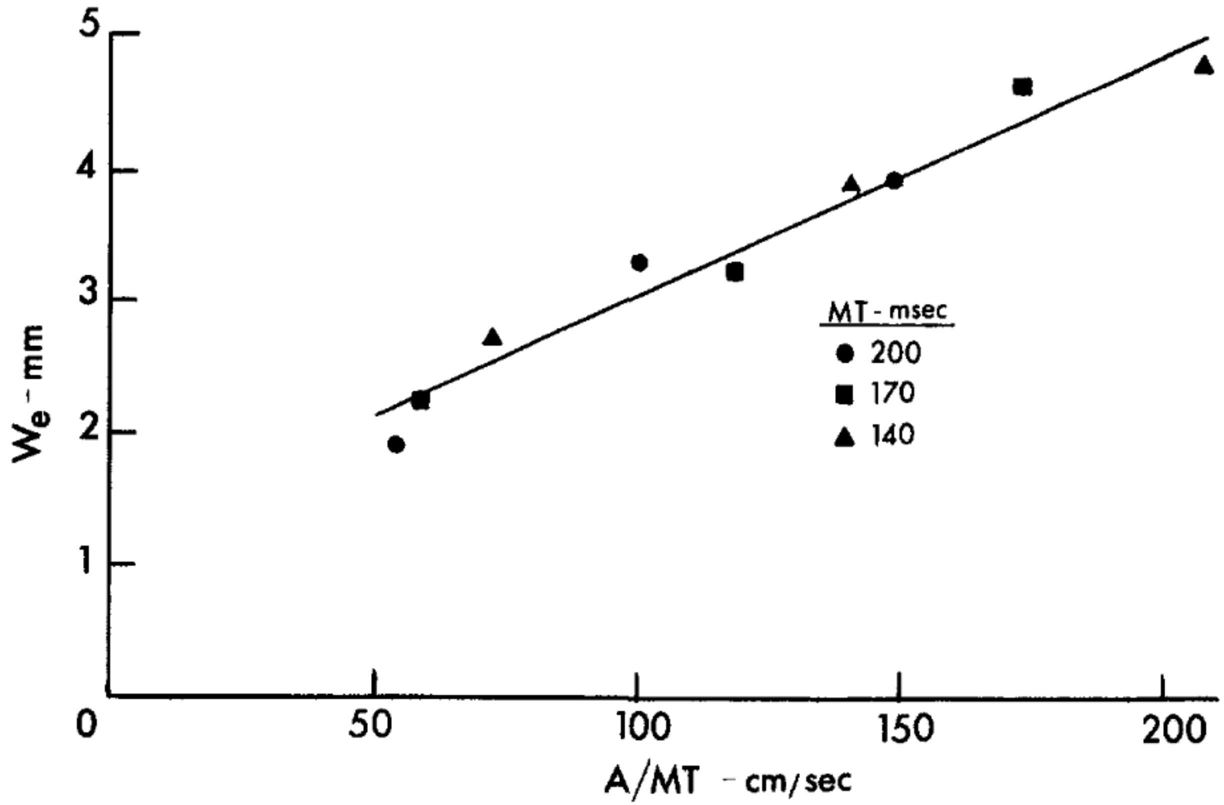
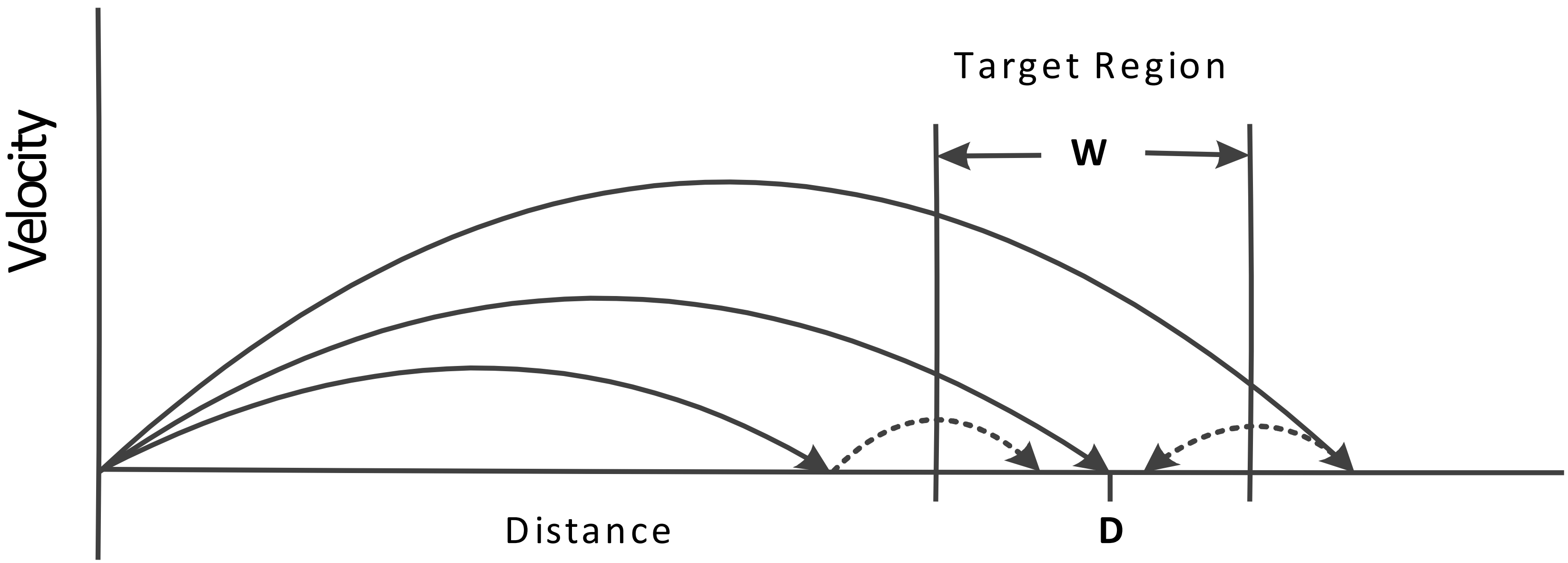


Figure 11. Effective target width (W_e) measured perpendicular to the direction of movement (direction error) as a function of the average velocity (A/MT).

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**

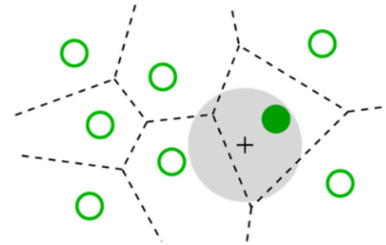
  3.1 GUI Essential Factors

  3.2 GUI Efficiency Models

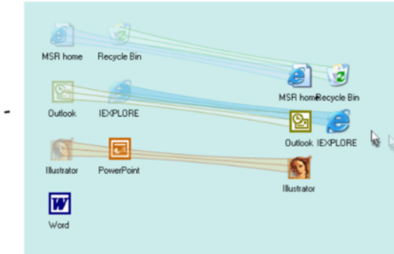
3.1 GUI Essential Factors

- **Pointing Device**
  (human movement to cursor)
  - Relative Pointing
    - Mouse/touchpad…
    - Eye/hand movement
    - Body gesture
  - Absolute Pointing (Surface)
    - Laser pointer
    - Pen
    - Finger touch
- **Pointer**
- **Widget Layout**

3.1 GUI Essential Factors

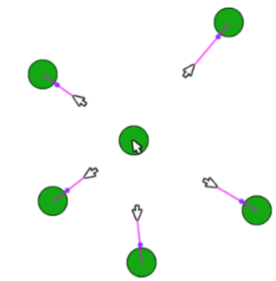


(a) Bubbe Cursor



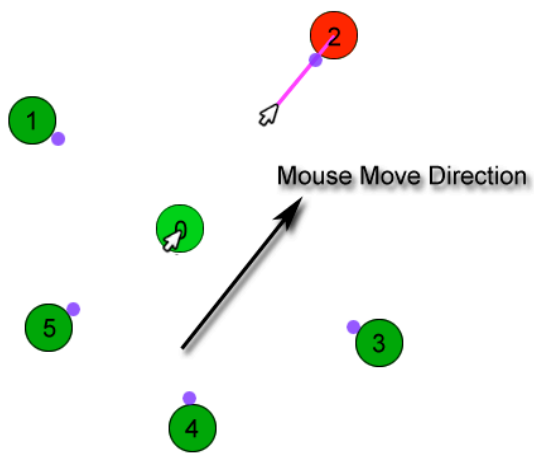
(b) Drag and Pop

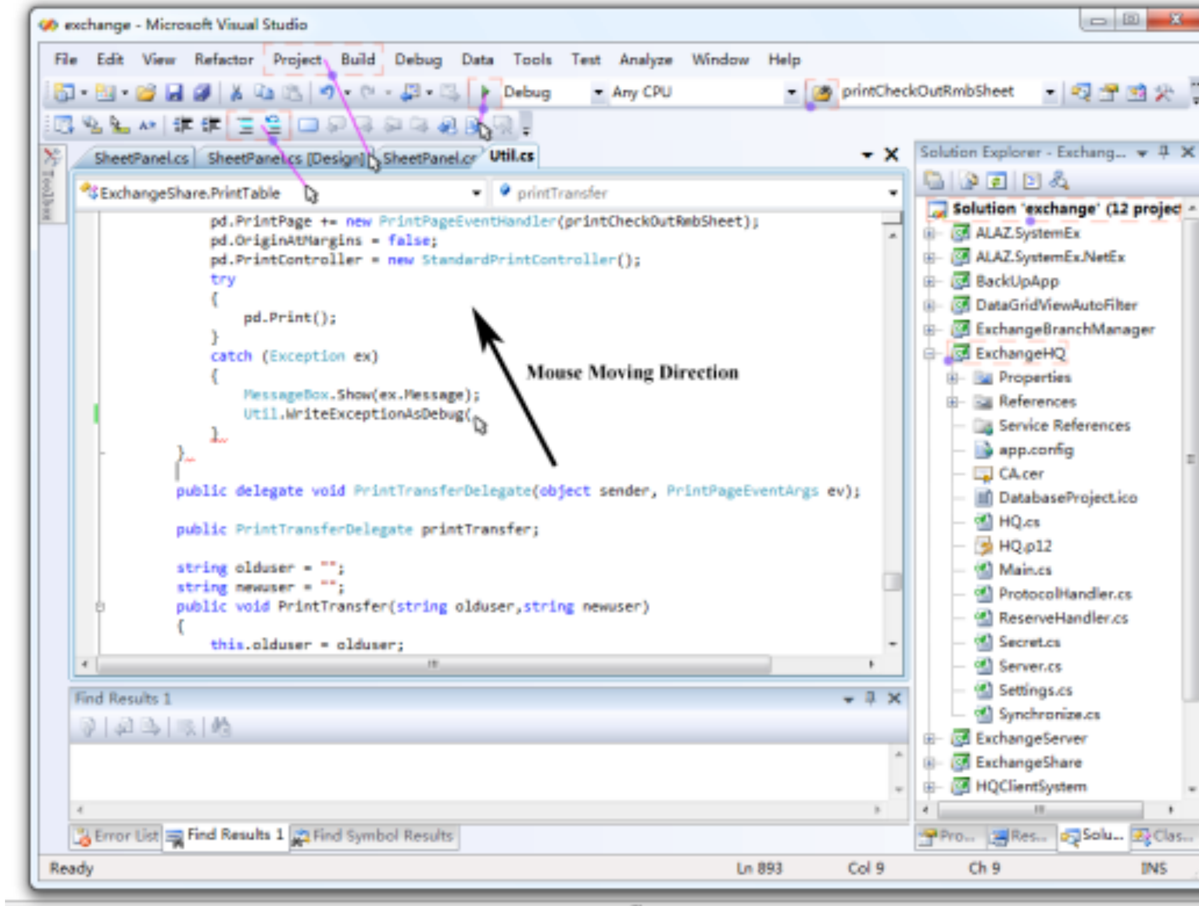
(c) Semantic Pointing



(d) Satellite Cursor

- **Pointing Device**
- **Pointer / 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）
- **Widget Layout**





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**log2n+1*

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= (cost of the LA-optical layout)/(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=$s_1, s_2, s_3 \ldots\ldots s_n$, command set =$\{c_1, c_2, c_3, \ldots c_m\}$
- CUI： $$T = \sum_{i=1}^{n} t(s_i) = \sum_{j=1}^{m} p_j * t(c_j)$$
- GUI： $$T = \sum_{i=1}^{n} t(s_i) = \sum_{j=1}^{m} p_j * \sum_{i=1}^{m} p_{(i|j)} * t(c_j \mid c_i)$$

GUI Efficiency Evaluation Model

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

命令c_j使用的频率

在命令序列中，c_j的前一个命令为c_i的概率

在上一个命令为c_i的情况下，完成命令c_j所需要的时间

优化交互效率 = **用户任务特性** ⟶ **界面布局**

GUI Efficiency Evaluation Model

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

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）

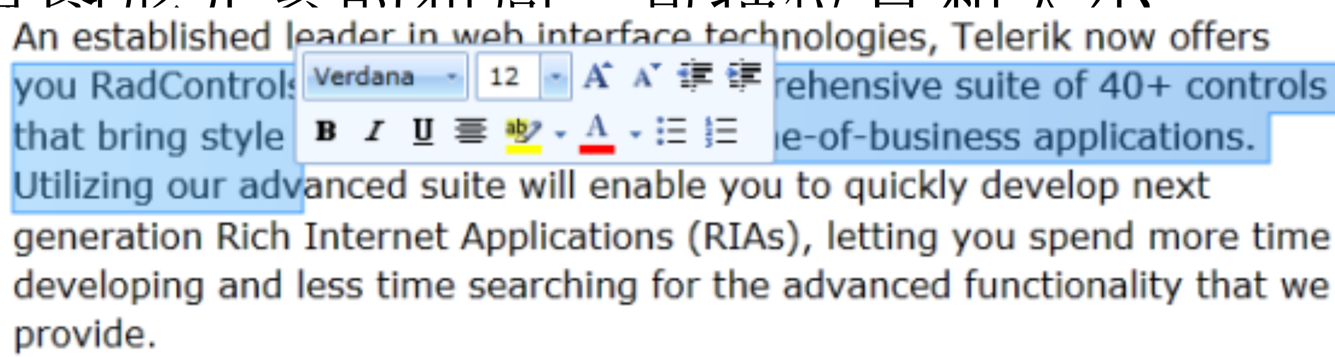
- 基本思想：将以高概率出现的特定序列压缩为短序列

GUI Efficiency Evaluation Model

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

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，包括位置和大小
- 已有案例：
  - Word浮动
- 风险：不断
- 策略：效率提升和学习成本的折衷



GUI Efficiency Evaluation Model

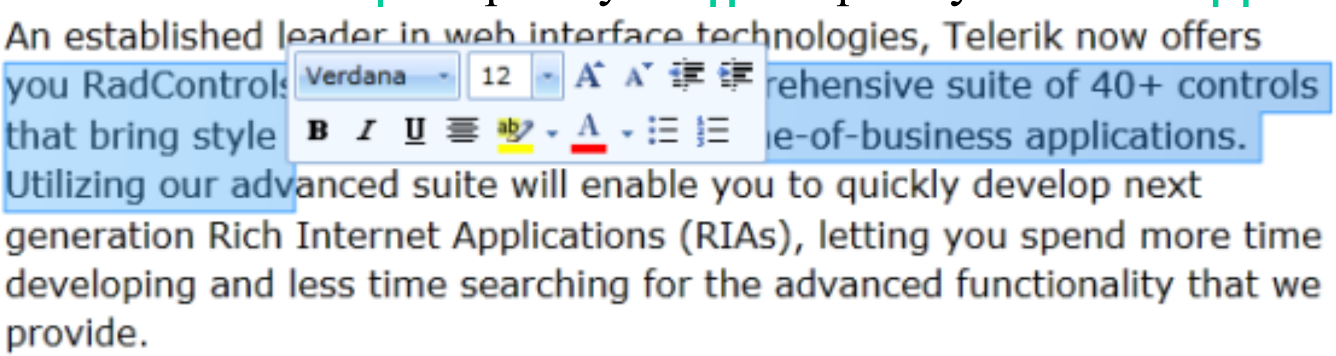
$$T = \sum_{i=1}^{n} t(s_i) = \sum_{j=1}^{m} p_j * \sum_{i=1}^{m} p_{(i|j)} * t(c_j \mid c_i)$$

Frequency of

Frequency of the

Time to complete c_j

ts previous c is c_i



Optimized UI = Feature of Task ⟶ UI Layout