Matematika in uporabniški grafični vmesniki

Matjaž Kljun

Vsebina

- Interakcija človek-računalnik
- Človeški dejavniki
- Fittsov zakon
- Zakon o krmiljenju
- Hickov zakon
- Model na ravni pritiska tipk (KLM)

- Human-computer interaction (HCI)
- Human factors
- Fitt's law
- Steering law
- Hick's law
- Keystroke-level model (KLM)

Opisni modeli /
Descriptive models

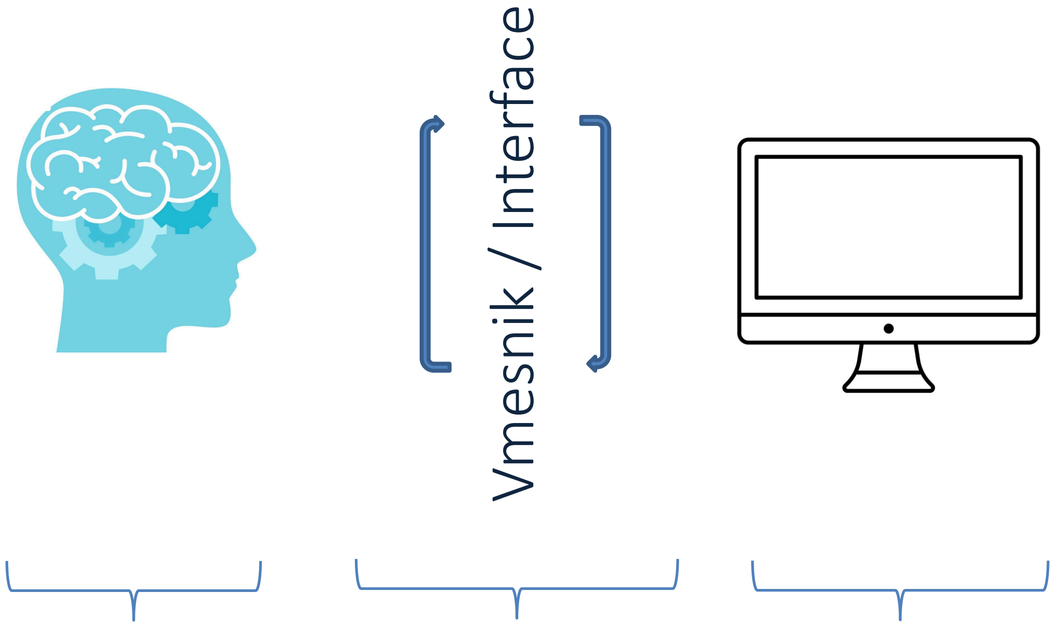
Napovedni modeli /
Predictive models

Analogija in metafora /
Analogy and metaphor

Matematične enačbe /
Mathematical equations

Kontinuum / Model Continuum Model (MCM)

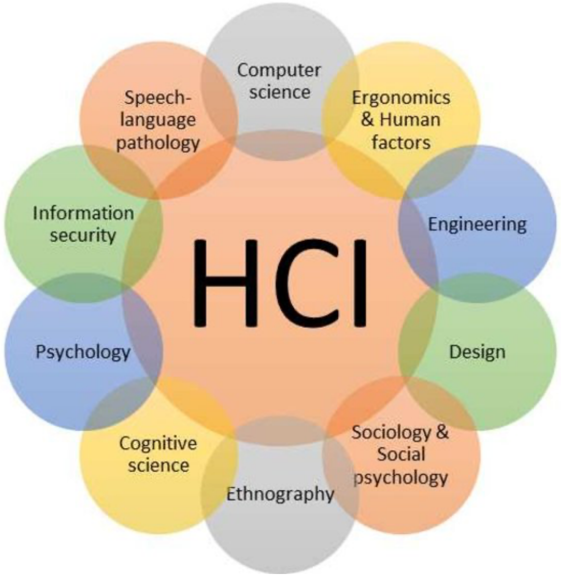
Interakcija človek-računalnik / Human-computer interaction (HCI)



Človek
Human

Interakcija
Interaction

Računalnik
Computer



- Računalništvo in informatika
- Ergonomija in človeški dejavniki
- Inženiring
- Oblikovanje
- Sociologija in socialna psihologija
- Etnografija
- Cognitivne znanosti
- Psihologija
- Varnost informacij
- Govorno-jezikovna patologija

https://www.vecteezy.com/free-vector/gear-head,

Človeški dejavniki in ergonomija / Human factors

- Človeški dejavniki so področje, ki raziskuje, kako fiziološke in psihološke značilnosti uporabnikov vplivajo na upravljanje izdelkov, procesov in sistemov.
- Z razumevanjem teh značilnosti lahko načrtujemo in oblikujemo izdelke, procese in sisteme po meri uporabnika, ki izvaja interakcijo z le-temi.
- Štirje glavni cilji pri tem so:
  - zmanjšanje človeških napak,
  - povečanje produktivnosti,
  - izboljšanje varnosti/razpoložljivosti sistema in
  - povečanje udobja uporabnika.

- Human factors studies how users' physiological and psychological characteristics influence their interaction with products, processes and systems.
- By understanding these characteristics, products, processes and systems can be designed and adapted to the user that interacts with them.
- The four main objectives in doing so are:
  - Reduction of human error,
  - increasing productivity,
  - improving system safety/availability, and
  - increasing user comfort.

Fittsov zakon / Fitts' law

Fitts, Paul M.
"The information capacity of the human motor system in controlling the amplitude of movement."
Journal of experimental psychology 47, no. 6 (1954): 381.

Fittsov zakon / Fitts’ law

- Paul Morris Fitts leta 1954 objavi članek z opisom modela človeškega gibanja.
- Raziskoval je vplive človeških dejavnikov in ergonomije pri letenju v Ameriških zračnih silah.
- Fittsov zakon je napovedni model gibanja in je do sedaj en najbolj raziskanih in uporabljenih modelov na tem področju.
- Najpogosteje ga uporabljamo pri oblikovanju vmesnikov – fizičnih in digitalnih.

- Paul Morris Fitts publishes a paper in 1954 describing a model of human movement.
- He was researching the effects of human factors and ergonomics on flight in the US Air Force.
- Fitts' law is a predictive model of motion and is one of the most researched and used models in this field to date.
- It is most commonly used in the design of interfaces - both physical and digital.

Osnove Fittsovega zakona / Fitt’s law basics

- Čas, potreben za premik na v naprej določeno ciljno območje, je funkcija razmerja med razdaljo (D) do sredine ciljnega območja in širino tega območja (W).

- The time to move to a predefined target area is a function of the ratio of the distance (D) to the centre of the target area and the width of the target area (W).

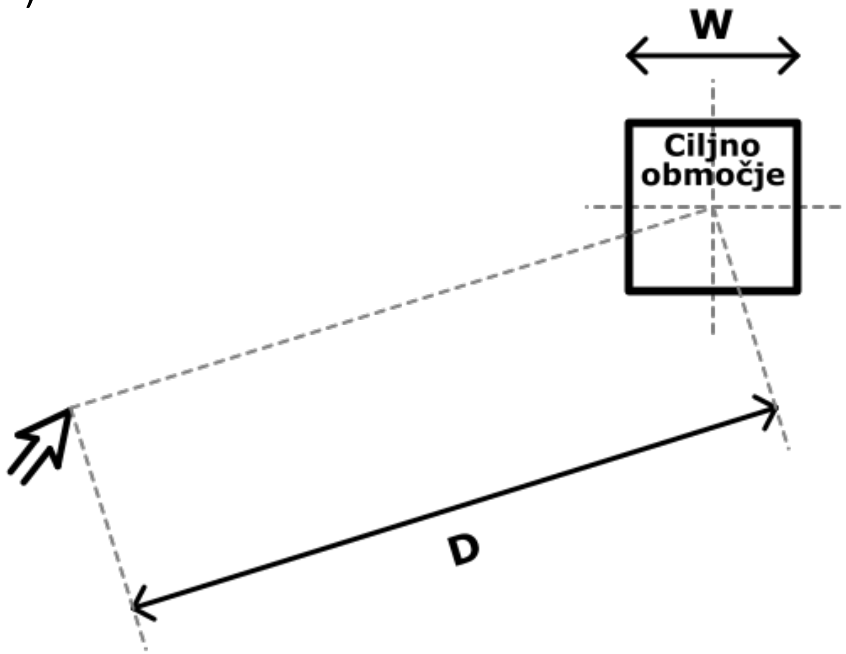


Image by Igor Schubin from Pixabay

Fittsov zakon in teorija informacij / Fitts' law and info theory

- Razdalja (D) = moč signala,
- Širina (W) = šum v danem signalu
- Formula modela temelji na dvojiškem algoritmu, ki se v teoriji informacij uporablja za določitev števila bitov, potrebnih za kodiranje določenega sporočila.
- Index težavosti:

- Distance (D) = signal strength,
- Width (W) = noise in a given signal
- The formula of the model is based on the binary algorithm used in information theory to determine the number of bits needed to encode a given message.
- Index of difficulty (or ID):

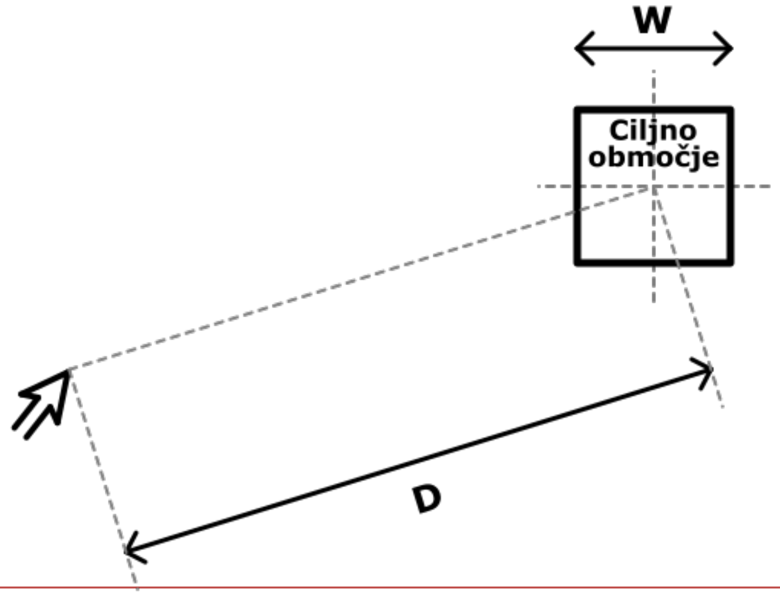
$$ID = log_2\left(\frac{D}{W/2}\right) = log_2\left(\frac{2D}{W}\right)$$ (tudi/also $ID = \log_2\left(\frac{D}{W} + 1\right)$)

MacKenzie, I. Scott. "Fitts' law as a research and design tool in human-computer interaction." Human-computer interaction 7, no. 1 (1992): 91-139.

Dodatna razlaga / Additional explanation

- Logaritemska funkcija = majhno povečanje velikosti ciljnega območja veliko bolj učinkovito za majhna ciljna območja kot za velika.
- Višina?

- Logarithmic function = a small increase in the size of the target area is much more effective for small target areas than for large ones.
- Height?

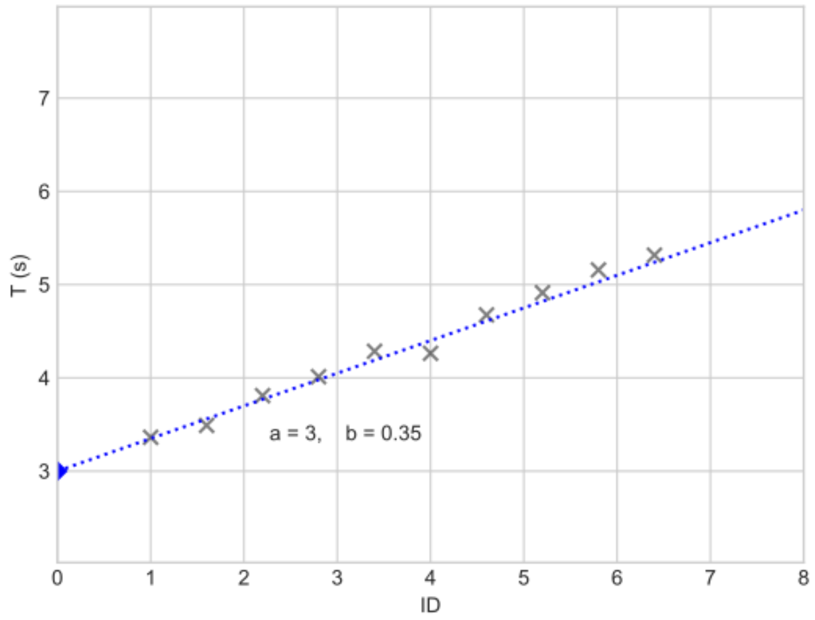


Čas za premik na ciljno območje / Time to reach the target

- Korelacija med časom izvajanja naloge in indeksom težavnosti:
- Correlation between time taken to complete the task and index of difficulty:

$$T = a + b * ID = a + b * log_2(\frac{2D}{W})$$

- *T* = čas premika na ciljno območje.
- *a* in *b* linearno odvisni konstanti, odvisni od vhodne naprave in določeni z opazovanjem.
- *b* je odvisen od naklona D in opisuje pospešek.
- *a* predstavlja zakasnitev



- T = time to move to the target area.
- *a* and *b* linearly dependent constants, dependent on the input device and determined by observation.
- *b* depends on the slope D and describes the acceleration.
- *a* represents the delay

Kje ga lahko uporabimo? / Where can we apply it?

- Pri premikih človeških delov telesa na ciljno območje (npr. premik prsta na stikalo za prižig luči, stopala na avtomobilsko zavoro).
- Za človeški pogled (npr. kako hitro najdemo s pogledom določeno informacijo na vmesniku).
- Za vnosne naprave na računalniških sistemih (npr. premik miškinega kazalca na določeno ikono na namizju računalniškega zaslona) .

- Velja tako za starejše kot mlajše uporabnike, uporabnike s posebnimi potrebami, uporabnike pod vplivom opiatov in celo pod vodno gladino.

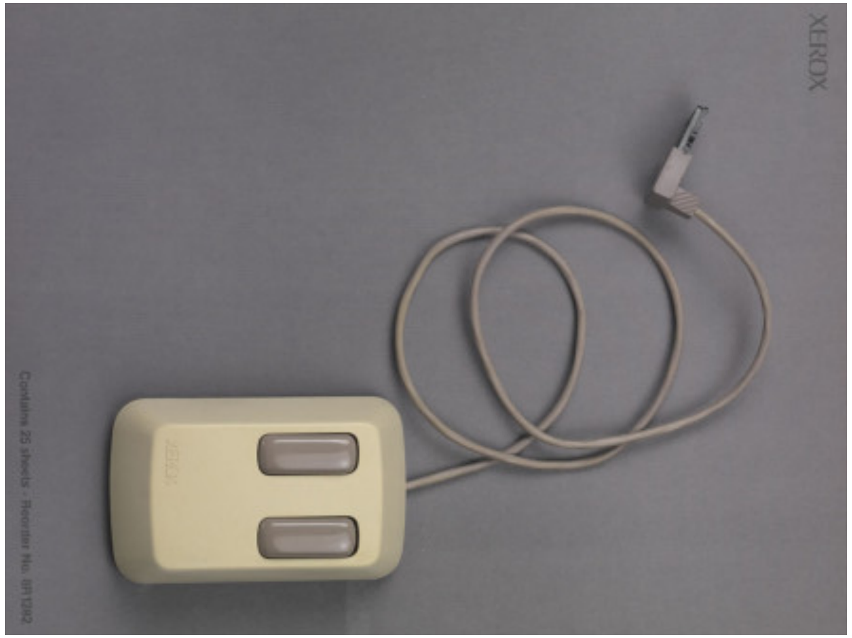
- Movements of the human body parts to the target area (e.g. finger on the light switch, foot on the car brake).
- For human gaze (e.g. how quickly can our gaze find a piece of information on an interface).
- For input devices on computer systems (e.g. moving the mouse pointer to a specific icon on the desktop of a computer screen)

- Applicable to both older and younger users, users with disabilities, users under the influence of opiates and even under water.

Xerox Star miška / Xerox Star mouse

- 1978 raziskava med hitrostjo vnosa z:
  - miško,
  - igralno palici in
  - smernimi tipkami

- 1978 study of task completion time with:
  - mouse,
  - joystick and
  - Direction keys



Fittsov zakon in uporabniški vmesniki / Fitts’ law and user interfaces

- Interaktivni elementi na zaslonu morajo biti oblikovani tako, da jih bo uporabnik karseda hitro in lahko dosegel ter kliknil nanje.

Posledično:

- Ciljno območje mora biti čimbliže začetnemu položaju miškinega kazalca.

- Širina ciljnega območja mora biti čim večja, da ga lahko uporabnik lažje doseže.

- Interactive elements on the screen should be designed to be reached and clicked on them as quickly and easily as possible.

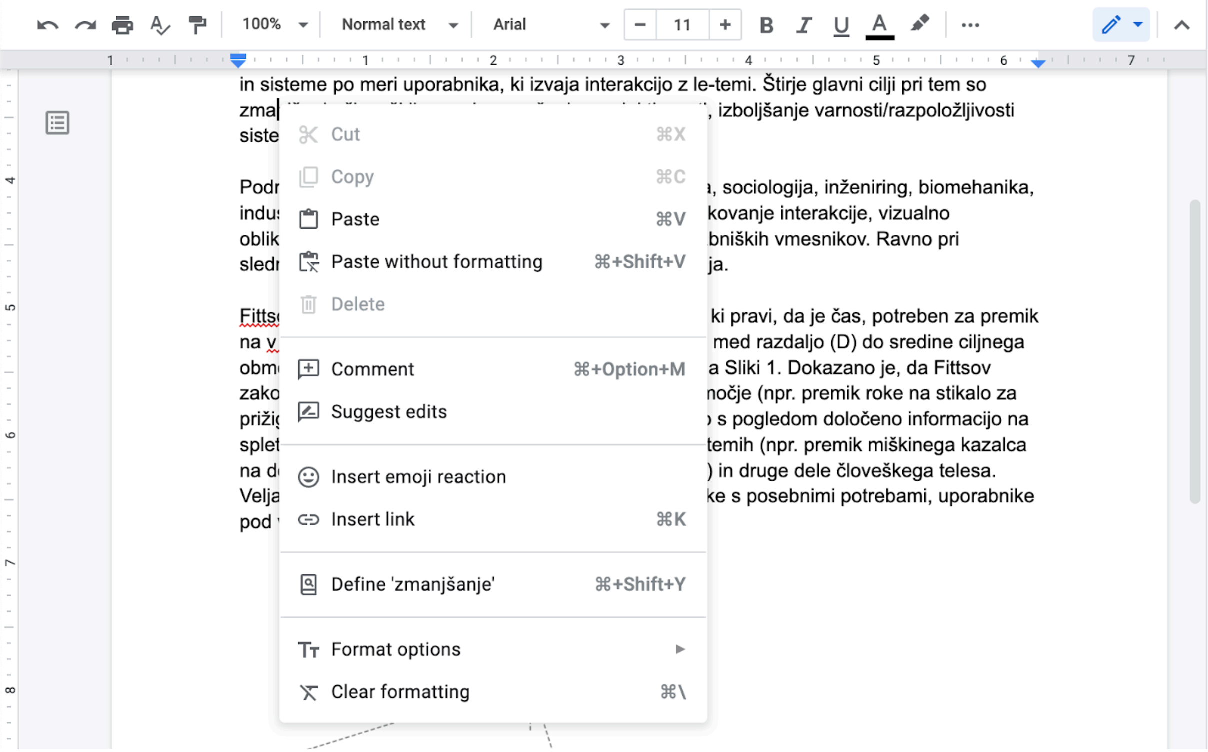
Consequently:

- The target area should be as close as possible to the initial position of the mouse cursor.
- The width of the target area should be as large as possible to make it easier for the user to reach it.

Primer 1 – čarobna točka / Example 1 – magic pixel

- Trenuten položaj miškinega kazalca D=0.
- Pojavni meniji

- Current cursor position D=0.
- Pop-up menus



- Zaporedni elementi postavljeni blizu

- Consequent elements close to each other

Primer 2 - neskončni robovi / Example 2 – infinite edges

- Pravilo neskončnih robov = na rob zaslona pridemo lahko z največjo možno hitrostjo premikanja miške in še vedno zadenemo cilj, saj je le-ta neskončen.
- macOS menijska vrstica in Dock.
  Windows opravilna vrstica.

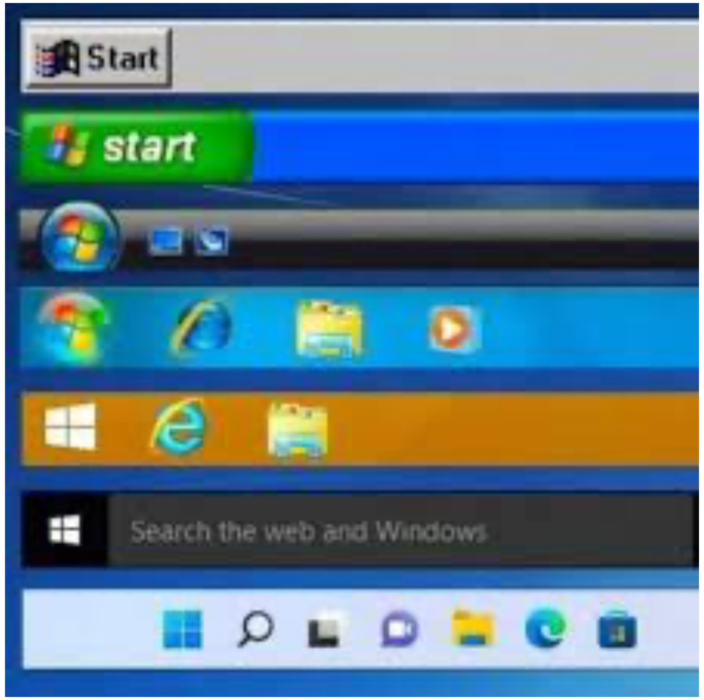
- The rule of infinite edges = you can get to the edge of the screen as fast as you can move the mouse and still hit the target, because it's infinite.
- macOS menu bar in Dock.
  Windows taskbar.

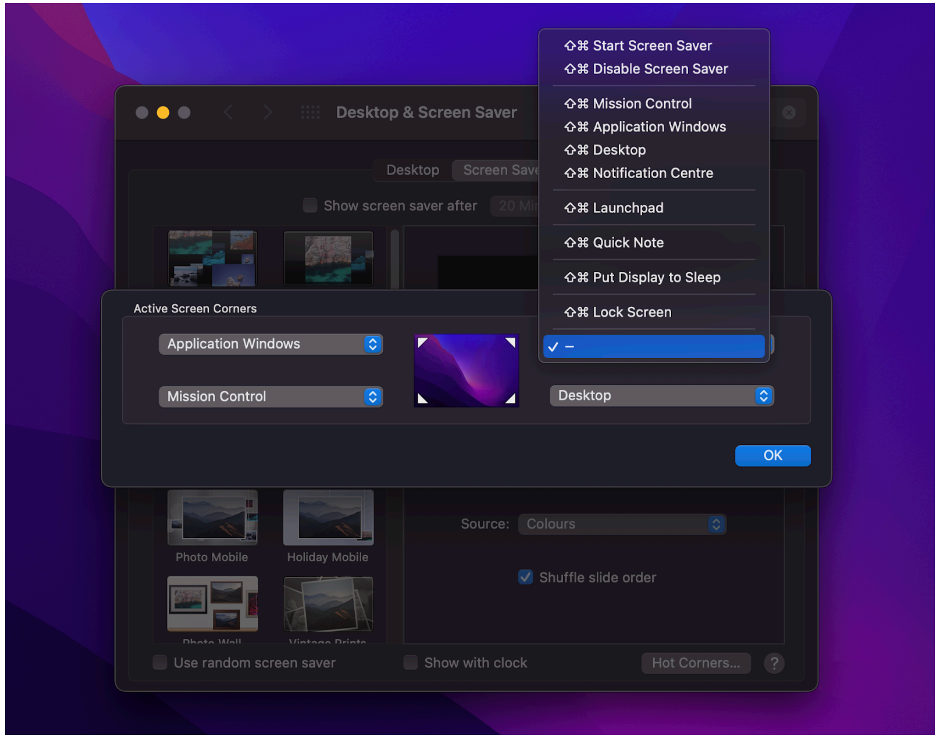
https://en.wikipedia.org/wiki/MacOS_Big_Sur

Primer 3 – čarobni vogali / Example 3 – magic corners

- Vogali namizja predstavljajo teoretično neskončno velik gumb (ciljno območje)
- Windows Start gumb. macOS vroči vogali.

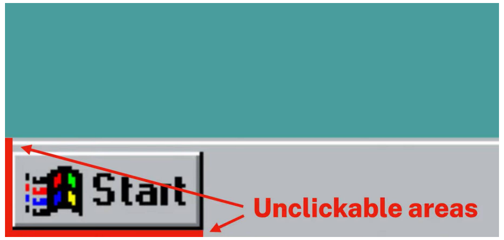
- The corners of the desktop are theoretically infinitely large button (target area).
- Windows Start button. macOS hot corners.



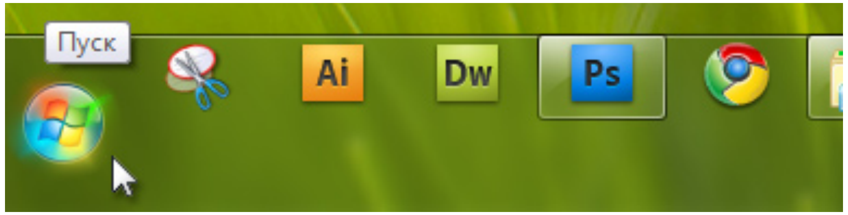


Windows Start in napake? / Windows Start and mistakes?

- Od Windows 95 do Windows XP je imel Start gumb dodaten rob.
- From Windows 95 to Windows XP, the Start button had an extra edge.



- Windows XP z dvignjeno opravilno vrstico.
- Windows XP with the taskbar rsaised.

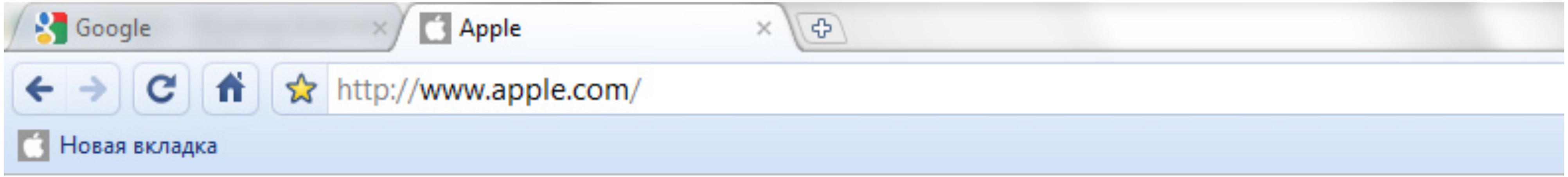


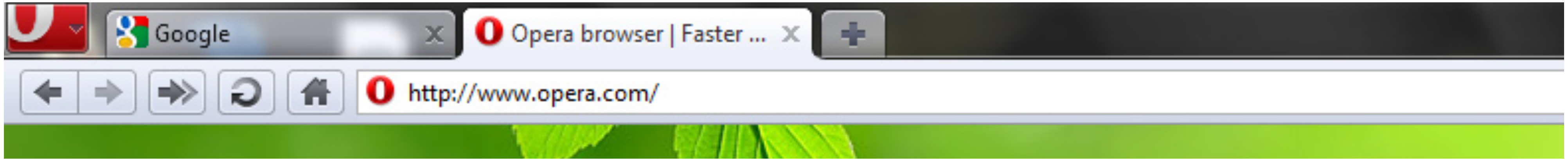
- Windows 11 - premaknjeno na sredino?
- Windows 11 - moved to the centre?

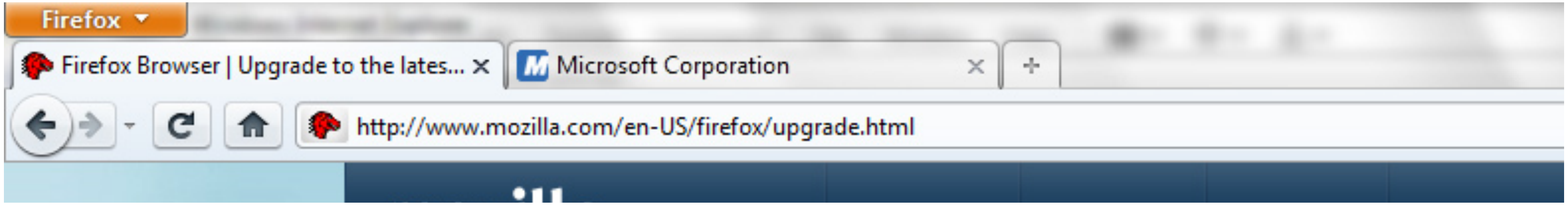
https://www.lovemedia.net/en/articles/fitts-law/

Brskalniki / Browsers

- Kje je težava? (Nekatere so bile tudi odpravljene)
- Where is the problem? (Some have been corrected)

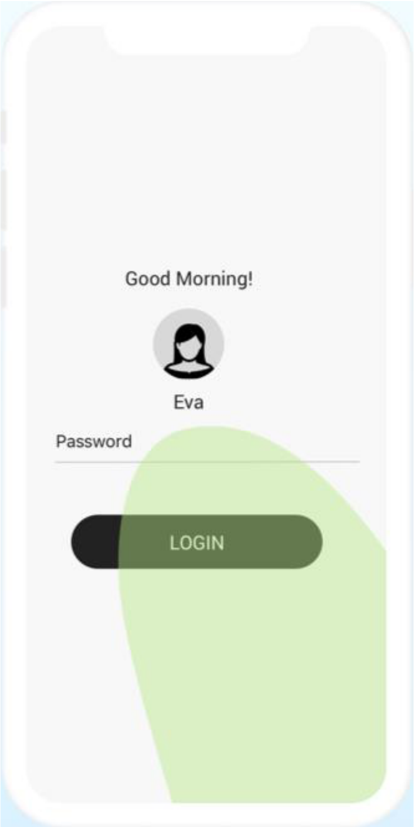






Fittsov zakon drugje / Fitts’ law in other areas

- Prvi iPhone – na podlagi izračunov so določili najmanjšo dovoljeno velikost posameznega gumba/ikone, ki je bila 44 pikslov na zaslonu 320x480 pikslov, pri čemer je indeks težavnosti pri tej velikosti znašal 1.38 (v Fittsovih raziskavah je najtežja naloga imela ID 16).
- Google iskalnik ima polje za iskanje na sredini zaslona, saj ga tam s pogledom najhitreje najdemo (za pogled je sredina zaslona pogosto glavni piksel).
- Na pametnih telefonih pri interakciji s palcem moramo poskrbeti, da so elementi v dosegu prsta. Na primer, ko beremo in s palcem premikamo besedilo.



- First iPhone – based on the experimentation they defined the minimum size of a button/icon, which was 44 pixels on a 320x480 pixel screen, with the index of difficulty 1.38 at this size (in Fitts' research, the most difficult task had an ID of 16).
- Google search engine has the search box in the centre of the screen, as this is where it is quickest to find it by our gaze (the centre of the screen is often the main pixel for gaze).
- On smartphones, when interacting with your thumb, we need to make sure that elements are within fingertip reach. E.g. when reading and dragging the text with the thumb.

Nevidno ciljno območje / Invisible target

Zakon o krmiljenju / Steering law

Accot, Johnny, and Shumin Zhai.
"Beyond Fitts' law: models for trajectory-based HCI tasks."
In *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems*, pp. 295-302. 1997.

Zakon o krmiljenju / Steering Law

- Napovedni model človeškega gibanja, ki opisuje čas, potreben za navigacijo v dvodimenzionalnem predoru.
- Predor je pot na ravnini s spreminjajočo se širino vzdolž poti.
- Cilj je čim hitreje krmariti skozi predor, pri čemer se ne smemo dotakniti robov predora.

- Izvira iz Fittsovega zakona.

- Predictive model of human movement that describes the time required to navigate through a 2D tunnel.
- The tunnel is a path on a plane with a varying width along the path.
- The aim is to navigate through the tunnel as quickly as possible, without touching the edges of the tunnel.

- Derived from Fitts law.

Čaz za dokončanje poti / Time required to traverse the path

- Splošna oblika

$$T = a + b \int_C \frac{ds}{W(s)}$$

  - T je povprečni čas, potreben za dokončanje poti
  - C je pot, ki jo določa parameter s
  - W(s) je širina poti pri s
  - a in b sta eksperimentalno določeni konstanti.

- General form

  - *T* is the average time to navigate the path
  - *C* is the path parameterized by *s*
  - *W(s)* is the width of the path at *s*
  - *a* and *b* are experimentally fitted constants.

- Enostavnejša oblika za enostavnejše poti

$$T = a + b\frac{A}{W}$$

  - A je dolžina poti
  - W je konstanta vzdolž poti

- Simpler form for simpler paths

  - A is the length of the path
  - W is constant along the path

Zakon o krmiljenju v menujih / Steering Law in drop-down menus

- Predor je vsaka pot, pri kateri mora uporabnik premikati kazalec miške (ali povleči prst) vzdolž poti, ki ima robove.
- Prekoračitev robov ima določene posledice. Na primer, ko smo s kazalecem izven predora, računalnik preneha biti pozoren.
- Širina predora vpliva na težavnost poti skozi predor - v ozkem predoru zlahka pomotoma zapustimo območje predora.

- A tunnel is any path requiring the user to move the cursor (or drag a finger) along a path that has borders.
- Overstepping the border will have some consequence, such as having the computer stop paying attention while the pointer is outside the tunnel.
- The width of the tunnel is important for how easily the user can steer through — a narrow tunnel makes it easy to accidentally exit the tunnel area.

Hierarhični meniji / Hierarchical menus

Potrebno je vedeti da:

- Zaradi človeške fiziologije je težko vzdrževati kazalec miške na ravni liniji: komolec in zapestje, ki omogočata gibanje roke, opisujeta lok in ne črte.
- Daljše kot je gibanje, večja je možnost napake.

Smernice:

- Padajoči meniji naj bodo čim krajši.
- Izogibajte se hierarhičnim menijem

Need to know that

- Maintaining the cursor on a straight path is hard due to human physiology: the elbow and wrist, which enable the movement of the hand, describe an arc, not a line
- The longer the motion, the greater the chance of error.

Guidelines:

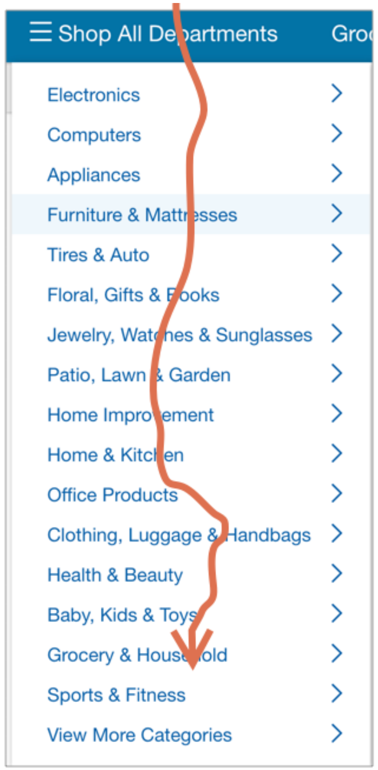
- Keep dropdown menus as short as possible
- Avoid hierarchical menus

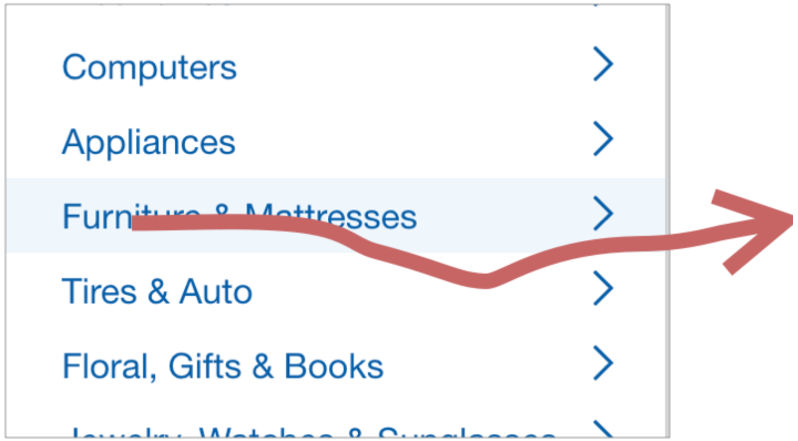
Smernice / Guidelines

- Navpični predor mora biti čim krajši (olajšamo navpično gibanje) in tanjši (olajšamo vodoravno gibanje).

- Nad in pod vsakim elementom menija vključimo čim več prostora, da povečamo širino predora za vodoravne gibe.
- Uporabimo kratek časovni zamik med premikom miške in prikazom otroškega menija.
- Dovolimo določeno mero napake pri diagonalnem gibanju.
- Uporabimo mega-menu.

- Večina menujev je tako široka kot je široko najdaljše besedilo in tako visoko kot je število kategorij. Optimizacija je redka!





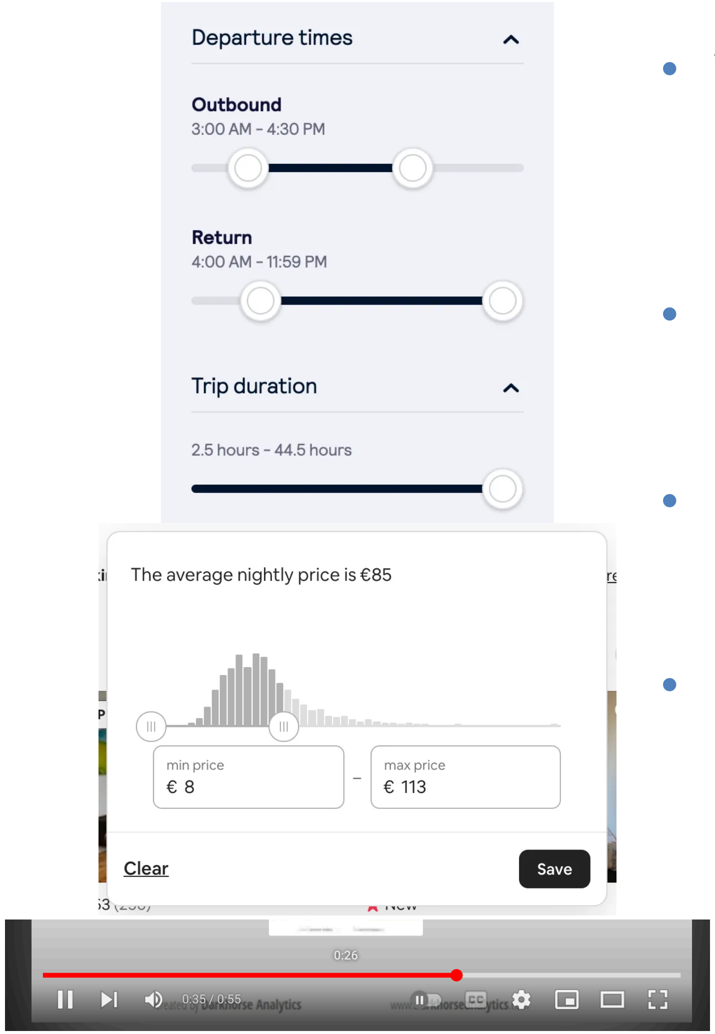
- The vertical tunnel should be as short as possible (to facilitate vertical movement) and as slim as possible (to facilitate horizontal movement).

- Include as much padding as reasonably possible above and below each menu item, to increase the width of the tunnel for horizontal movement.
- Use a short time delay between mouse hover and revealing the child menu
- Allow some error in diagonal movement.
- Use mega-menu.

- Most menus are as wide as the longest text and as high as the number of categories. Optimisation is rare!

Zakon o krmiljenju in drsniki / Steering Law and sliders

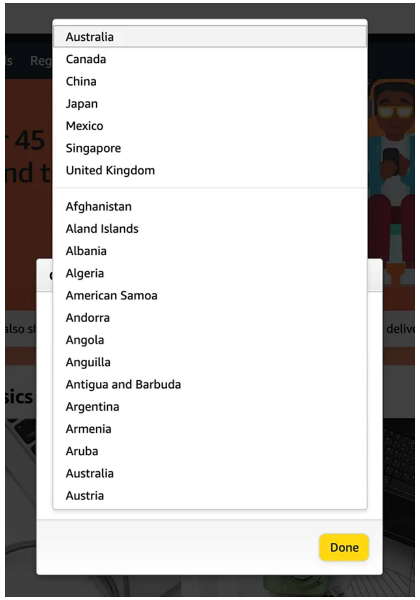
- Drsnike oblikujemo tako, da tudi če gremo iz območja drsnika, le-ta še vedno sledi kazalcu.
- Zagotovimo sekundarni fini nadzor (npr. vnosno polje in koračne gumbe).
- Uporabnikom omogočimo klikniti kjer koli na drsniku, da preskočijo na želeni položaj.
- Zagotovimo dovoljšnjo velikost gumbov drsnika (zlasti na zaslonih na dotik) in da kurzor/prst ne zakriva informacij.

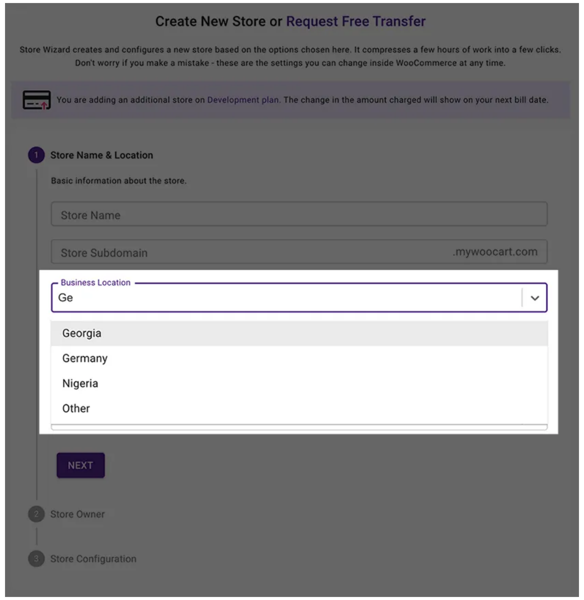


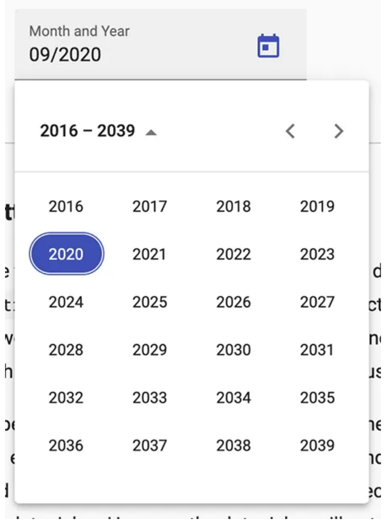
- The sliders should be designed in such a way that even if we go out of the slider area, the slider still follows the cursor.
- Provide a secondary fine control (e.g. numeric input box & stepper buttons).
- Allow users to click anywhere on the slider to jump to the desired position.
- Ensure the considerable size (especially on touchscreens) of the slider knob and that the cursor/finger won't obscure the information.

https://uxdesign.cc/better-controls-and-interaction-with-accot-zhai-steering-law-eb729de7e8cb

Zakon o krmiljenju in spustni meniji / Steering Law and dropdown







- Tudi dolgi navpični premiki so lahko težavni in zahtevajo veliko časa za vnos.
- Meni naj bo sortiran.

- Long vertical movements can be difficult and require a lot of time for input.
- Menu should be sorted.

Hickov zakon / Hick’s (Hick–Hyman) law

Hick, William E.
"On the rate of gain of information."
Quarterly Journal of experimental psychology 4, no. 1 (1952): 11-26.

Hyman, Ray.
"Stimulus information as a determinant of reaction time."
Journal of experimental psychology 45, no. 3 (1953): 188.

Hickov (Hick-Haymanov) zakon / Hick’s (Hick-Hayman) lay

- Psihologa William Edmund Hick in Ray Hyman leta 1952 in 1953
- Zakon pravi, da več kot je dražljajev (ali izbir), s katerimi se srečamo, dlje časa potrebujemo za odločitev.
- Zakon pravi tudi, da povečanje števila izbir podaljša čas odločanja logaritemsko.
- Vendar študije kažejo, da se reakcijski čas iskanja besede na naključno urejenem seznamu povečuje linearno glede na število postavk.

- Psychologists William Edmund Hick and Ray Hyman in 1952 an 1953
- The law states that the more stimuli (or choices) we face, the longer it will take us to make a decision.
- The law also states that increasing the number of choices will increase the decision time logarithmically.
- However, studies suggest that the reaction time of the search for a word within a randomly ordered list increases linearly according to the number of items.

Reakcijski čas / Reaction time

$$T = b \cdot \log_2(n + 1)$$

- *T* je reakcijski čas
- *n* je število enako verjetnih izbir
- *b* je empirično določena konstanta
- Dodatek *1* k *n* upošteva negotovost glede tega, ali se odzvati ali ne, pa tudi glede tega, kateri odziv izvesti.

Hickov zakon je najzanesljivejši pri naključnem iskanju po seznamih, kjer uporabnik ne more uporabiti iskalne strategije, ki bi mu omogočila osredotočanje na izolirano območje vseh razpoložljivih možnosti (npr. abecedno ali številčno urejen seznam).

- T is a reaction time
- *n* is the number of equally probable choices
- *b* is a constant determined empirically
- Addition of *1* to *n* takes into account the "uncertainty about whether to respond or not, as well as about which response to make.”

Hick's law is most robust when applied to random searching in lists where the user cannot employ a search strategy that allows them to focus on an isolated region of all available options (e.g. alphabetically ordered list or items in numerical order).

Nekaj napotkov na podlagi zakona / Some guidelines based on the law

- Zmanjšamo število in poenostavimo možnosti, ki so na voljo uporabnikom (včasih se zapletenosti ni mogoče izogniti), na primer z združevanjem elementov na zaslonu na razumljiv način.
- Vsaka možnost na vmesniku mora biti dostopna in lahko razločljiva (uporabniku ni potrebno prebirati nepomembno vsebino, da bi lahko začeli z delom).
- Vse ključne informacije morajo biti takoj vidne in dostopne na prvi pogled: skrijemo vse, kar ni potrebno.

- Decrease and simplify the options available to users (sometimes there is no avoiding complexity), for instance, by grouping items on a screen in a understandable manner.
- Any option offered in the interface should be accessible and easily decipherable (users should not need to trawl irrelevant material simply to get started).
- All critical information needs to be readily visible and accessible at a glance: conceal anything that isn’t necessary.

Mega-menuji / Mega menus

Sign In | English | Order Status

THE NORTH FACE

Sale Men's Women's Kids' Bags & Gear Renewed About Us

Women's

Shop All Women's

Sale

Featured

- New Arrivals
- Best Sellers
- Plus Sizes
- Black History Month
- Low-Fi Hi-Tek

Shop By Activity

- Snow
- Hike
- Trail Run
- Climb
- Camping

Jackets & Vests

- Insulated
- Snow
- Rain
- Vests
- Parkas
- Triclimates
- Softshell

Fleece

- Full Zip
- Pullover

Tops

- Hoodies & Sweatshirts
- T-Shirts
- Active
- Tank Tops

Bottoms

- Pants
- Snow
- Leggings
- Shorts
- Dresses & Skirts
- Sweatpants & Joggers

Footwear

- Hike
- Winter Boots
- Trail Run
- Boots
- Slippers
- Sandals

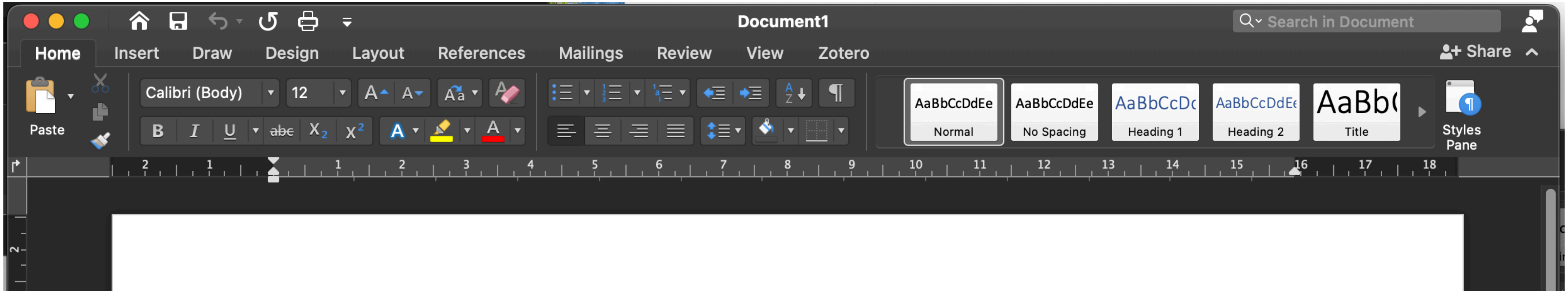
Accessories

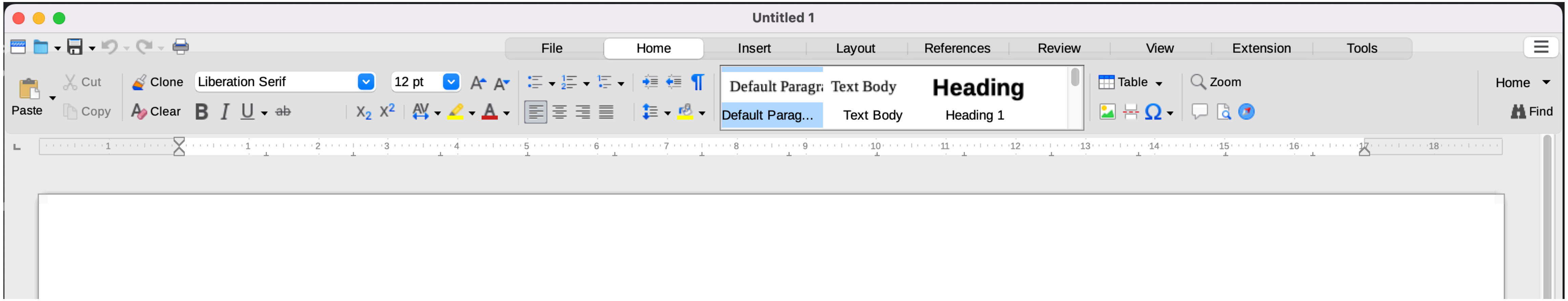
- Gloves
- Beanies
- Hats
- Smartwool Socks
- Scarves & Gaiters

Collections

- Summit Series™
- Our Icons

Trakovni menu / Ribbon menu or Tabbed menu





Model na ravni pritiska tipk / Keystroke-level model (KLM)

Card, Stuart K., Thomas P. Moran, and Allen Newell.
"The keystroke-level model for user performance time with interactive systems."
Communications of the ACM 23, no. 7 (1980): 396-410.

Opis modela / Description of the model

- Eden najobsežnejših napovednih modelov v literaturi o HCI, razvit posebej za analizo človeškega delovanja v interaktivnih računalniških sistemih.
- Napove, koliko časa bo izkušeni uporabnik potreboval, da bo brez napak opravil rutinsko nalogo z uporabo interaktivnega računalniškega sistema iz naslednjih elementov:
  - Naloga (ali vrsta podnalog)
  - Uporabljena metoda
  - Ukazni jezik sistema
  - Parametri motoričnih spretnosti uporabnika
  - Parametri odzivnega časa sistema

- One of the most comprehensive predictive models in the HCI literature, developed specifically for analysing human performance in interactive computing systems.
- Predicts how long it will take an expert user to accomplish a routine task without errors using an interactive computer system using the following elements:
  - Task (or series of sub-tasks)
  - Method used
  - Command language of the system
  - Motor skill parameters of the user
  - Response time parameters of the system

Predviden čas izvedbe / Predited execution time

- Model je uporaben, ko je znano zaporedje interakcij pri izvajanju določene naloge.
- Nalogo je treba razdeliti na podnaloge oz. primitivne operacije.
- Skupni predvideni čas je vsota časov primitivnih operacij.

- The model is useful in situations where the sequence of interactions in performing a task is known.
- A task needs to be broken down into a series of subtasks, or primitive operations.
- The total predicted time is the sum of the subtask times.

$$T_{execute} = \sum_{op \in OP} n_{op} \times op$$

- Model deluje znaslenjimi operatorji:
  - 4 motoričnimi (K = tipkanje, P = kazanje, H = ponastavjanje, D = risanje),
  - 1 miselni (M),
  - 1 sistemski odzivni operator (R).
  - ...
  - Nekateri dodajo še klik miškinega gumba (B).

- The model works with:
  - four motor-control operators (K = keystroking, P = pointing, H = homing, D = drawing),
  - one mental operator (M),
  - and one system response operator (R).

  ...
  - Some add pressing/clicking a mouse button (B)

Operatorji in vrednosti / Operators and values

Operator	Description	Associated Time
K	Keystroke, typing one letter, number, etc. or function key like ‘CTRL’, ‘SHIFT’	Expert typist (90 wpm): 0.12 sec Average skilled typist (55 wpm): 0.20 sec Average non-secretarial typist (40 wpm): 0 .28 sec Worst typist (unfamiliar with keyboard): 1.2 sec
H	‘Homing’, moving the hand between mouse and keyboard	0.4 sec
B / BB	Pressing / clicking a mouse button	0.1 sec / 2*0.1 sec
P	Pointing with the mouse to a target	0.8 to 1.5 sec with an average of 1.1 sec Can also use Fitts’ Law
$D(n_D, l_D)$	Drawing n_D straight line segments of length l_D	$0.9 * n_D + 0.16 * l_D$
M	Subsumed time for mental acts; sometimes used as ‘look-at’	1.35 sec (1.2 sec according to [Olson and Olson 1995])
R(t) or ***W(t)***	System response (or ‘work’) time, time during which the user cannot act	Dependent on the system, to be determined on a system-by-system basis

https://www.medien.ifi.lmu.de/lehre/ss10/mmi1/MMI1-SS10-07-Basic-HCI-Models-2.pdf

Čas izvedbe naloge 1 / Execution time for task 1

Naloga: vnos naslova v besedilno polje na spletnem obrazcu za povprečnega uporabnika.

Task: enter an address in the text box on the web form for an average user.

1. Poiščemo ustrezno besedilno polje (M)
2. Začetek vnosa (M)
3. Postavimo kazalec na pravilno polje (P)
4. Kliknemo na gumb miške (B)
5. Spustimo gumb miške (B)
6. Premaknemo roke na tipkovnico (H)
7. Vnesemo “Glagoljaška 8” (13K)

1. Find the correct text field (M)
2. Initiate the entry (M)
3. Point to the correct field (P)
4. Press mouse button (B)
5. Release mouse button (B)
6. Move hands from mouse to keyboard (H)
7. Type “Glagoljaška 8” (13K)

$$T = 2M + P + 2B + H + 13K = 2*1{,}35 + 1{,}1 + 2*0{,}1 + 0{,}4 + 13*0{,}2 = 7\ s$$

Čas izvedbe naloge 2 / Execution time for task 2

- V programu MS Word 2003 dodajmo presledek 6pt za trenutnim odstavkom.
- In MS Word 2003, add a 6pt space after the current paragraph.

Actions	Operator (keyboard)	Time allocated	Operator (mouse)	Time allocated
Locate menu 'Format'	*M*	1.35	*M*	1.35
Press ALT-o or mouse click	*K*,*K*	2*0.28	*P*,*B*	1.10+0.10
Locate entry 'Paragraph'	*M*	1.35	*M*	1.35
Press 'p' or mouse click	*K*	0.28	*P*,*B*	1.10+0.10
Locate item in dialogue	*M*	1.35	*M*	1.35
Point to item	*K*,*K*	0.28	*P*,*B*	1.10+0.10
Enter a 6 for a 6pt space	*K*	0.28	*K*	0.28
Close the dialogue (ENTER)	*K*	0.28	*K*	0.28
	Sum (keyboard): 5.73 sec.		**Sum (mouse): 8.21 sec.**	

- In MS Word 2007
- In MS Word 2007

Sum (keyboard): 7.22 sec.

Sum (mouse): 7.65 sec.

Posodobitve / Updates

- Operator premikanja miške (P) je konstanta = 1,10 s. Dodatna natančnost s Fittsovim zakonom:

- The pointing operator (P) is a constant of 1.10 s. Additional fidelity with a Fitts' law:

$$t_P = 0.159 + 0.204 \times \log_2\left(\frac{D}{W} + 1\right)$$

- Novi operatorji so dodani v različnih razširjenih KLM. Npr.:
  - t_{INT}: interval med preklopom načina z nedominantno roko in začetkom naslednjega dejanja.
  - t_{RF}: "doseči daleč", čas, v katerem sežemo od avtomobilskega volana do sistema IVIS.

- New operators are added in various extended KLMs. E.g.:
  - t_{INT}: the interval between a mode switch with the non-dominant hand and the beginning of the next action.
  - t_{RF}: "reach far," the time to reach from a car's steering wheel to an IVIS.

Prednosti in slabosti KLM / Pros and cons of KLM

- Samo za dobro opredeljene rutinske kognitivne naloge
- Ne upošteva spodrsljajev ali napak, utrujenosti, socialnega okolja, ...
- Novi operatirji morajo biti dodani za modeliranje novih načinov interakcij.
- KLM velja za izkušene uporabnike, ki nalogo opravljajo prvič. Pri pretirano naučenih nalogah se lahko M izpusti.

- Če običajna opravila trajajo predolgo ali so sestavljena iz prevelikega števila operatorjev, je smiselno ponuditi uporabnikom bližnjice.
- Napovedi so večinoma izjemno natančne: +/- 20%

- Only for well defined routine cognitive tasks
- Does not consider slips or errors, fatigue, social surroundings, ...
- To model novel interactions new operators need to be added
- The KLM applies to expert users doing a task for the first time. In overlearned tasks M could be omitted.

- If common tasks take too long or consist of too many operators, shortcuts can be provided
- Predictions are mostly remarkable accurate: +/- 20%

Drugi modeli in uporaba matematike / Other models and uses of math

- Splošna uporaba statistike pri izdelavi vmesnikov. https://alandix.com/statistics/

Napovedni modeli:

- Linearni regresijski model - izraža linearno povezavo med neodvisno spremenljivko (x, napovedna spremenljivka) in odvisno spremenljivko (y, kriterijska spremenljivka ali človeški odziv). https://en.wikipedia.org/wiki/Linear_regression
- Model človeškega procesorja - metoda kognitivnega modeliranja za izračun, koliko časa je potrebno za izvedbo naloge. https://en.wikipedia.org/wiki/Human_processor_model

- The general use of statistics in user interfaces https://alandix.com/statistics/

Predictive models:

- Linear regression model - expresses a linear relationship between an independent variable (x, a predictor variable) and a dependent variable (y, a criterion variable or human response) https://en.wikipedia.org/wiki/Linear_regression
- Human processor model - a cognitive modeling method to calculate how long it takes to perform a certain task. https://en.wikipedia.org/wiki/Human_processor_model

Drugi modeli in uporaba matematike / Other models and uses of math

- GOMS - široko uporabljena metoda, ki napoveduje kako bodo ljudje uporabljali predlagani računalniški sistem. https://en.wikipedia.org/wiki/GOMS
- Večkratna regresija (model napovedi, pri katerem se izid napoveduje na podlagi več napovednih dejavnikov (modelov, zakonov))

Opisni modeli:

- Model ključnih dejanj
- Kvadrantni modeli za razmejitev problemskega prostora.
- Model dvo-ročnega nadzora
- Model treh stanj za grafični vnos
- Zakon moči učenja (ali prakse)

- GOMS - a widely used method for quanti- and qualitative predictions of how people will use a proposed computer system. https://en.wikipedia.org/wiki/GOMS
- Multiple regression (a prediction model where the outcome is predicted from multiple predictors (models, laws))

Descriptive models:

- Key-action model (KAM)
- Quadrant model for delineating a problem space
- Model of bimanual control
- Three-state model for graphical input
- Power law of learning (or practice)

Iztočnice / Conclusions

- Matematika je uporabna pri razumevanju in modeliranju uporabnikovega vedenj, vključno s številnimi drugimi disciplinami.
- Noben od naštetih zakonov, modelov, smernic ne deluje osamljeno – pri oblikovanju vmesnikov je potrebno upoštevati mnogo dejavnikov, vključno z modnimi smernicami.
- Najboljši vmesnik je tisti, ki ga ne opazimo. Ne pozabimo, da uporabniki na koncu le želijo karseda hitro dokončati zastavljene naloge.

- Mathematics is useful in understanding and modelling user behaviour, but so are several other disciplines.
- None of these laws, models, guidelines work in isolation - there are many factors to consider when designing interfaces, including fashion guidelines.
- The best interface is the one that is not noticed. Let's not forget that, at the end of the day, users want just to complete their tasks as quickly as possible.

Vprašanja

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DODATNO BRANJE / FURTHER READING

MacKenzie I. S. "Human-computer interaction: An empirical research perspective." (2012).

- Matematika je uporabna kot podpora pri razumevanju človeških dejavnikov.
- Nobena smernica ne deluje osamljeno.
- Najboljši vmesnik je tisti, ki ga ne opazimo.

- Mathematics is useful as a support for understanding human factors.
- No guideline works in isolation.
- The best interface is invisible.