Assignment 1 - Modelling Target Movement Time in HCI using Fitts's Law

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In 1954, psychologist Paul Fitts, examining the human motor system, showed that the time required to move to a target depends on the distance to it, yet relates inversely to its size. By his law, fast movements and small targets result in greater error rates, due to the speed-accuracy trade-off.

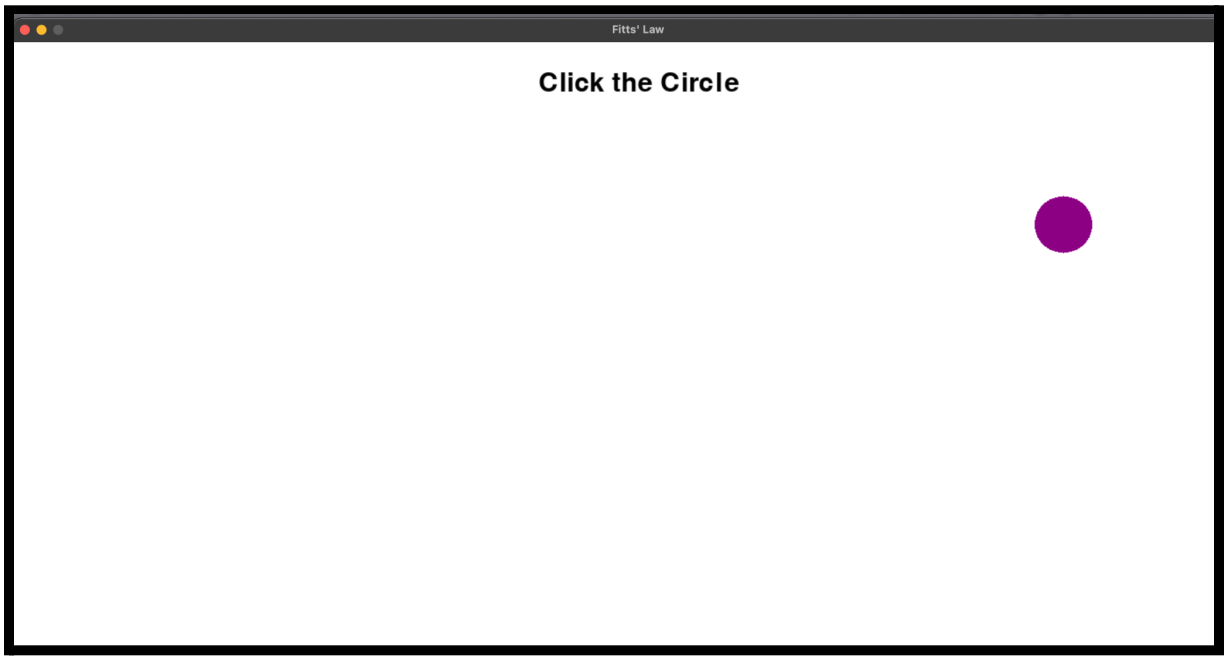
MT = a + b log 2 (2A / W) where

W : Width of the target measured along the axis of motion

A : Distance from the starting point to the centre of the target

Fitts' law is widely applied in user experience (UX) and user interface (UI) design. For example, this law influenced the convention of making interactive buttons large (especially on finger-operated mobile devices)—smaller buttons are more difficult (and time-consuming) to click. Likewise, the distance between a user's task/attention area and the task-related button should be kept as short as possible.

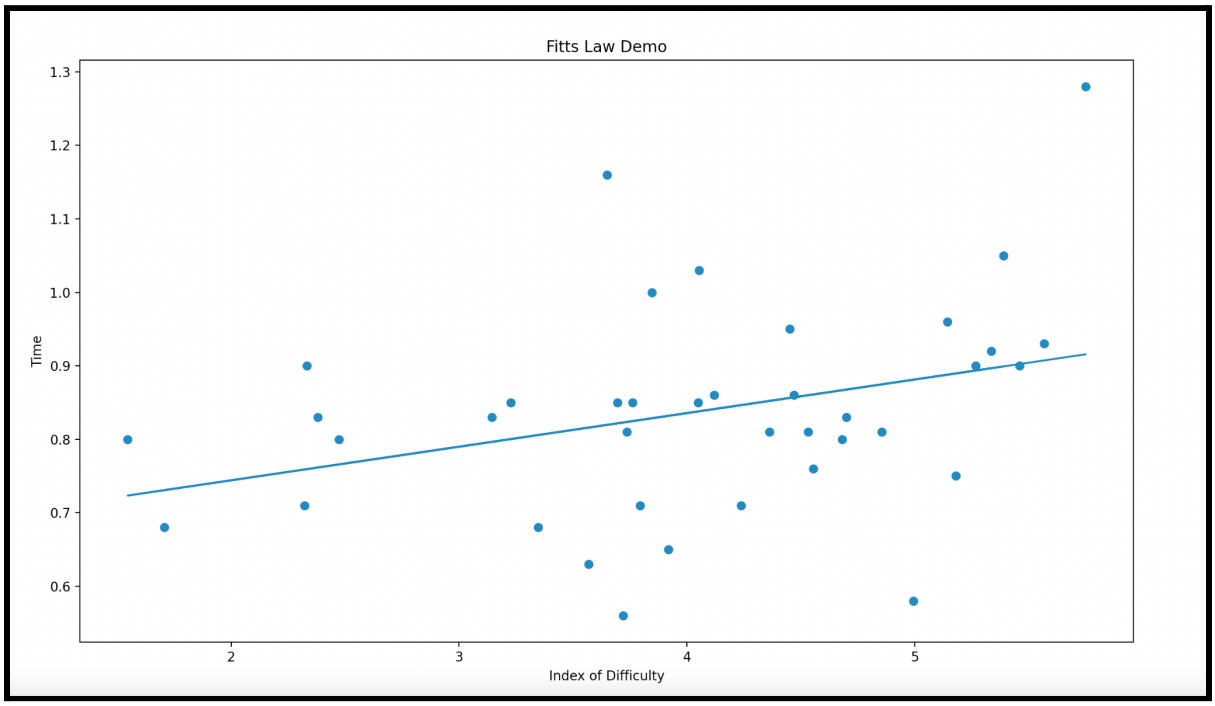
The term **log 2 (2A / W)** is called the **index of difficulty (ID)**. It describes the difficulty of the motor tasks. 1/b is also called the **index of performance (IP)** and measures the information capacity of the human motor system.



Screenshot of GUI

When you click on the circle shown above, another circle with a random radius and colour appears in a random spot.
This is repeated for 40 circles.

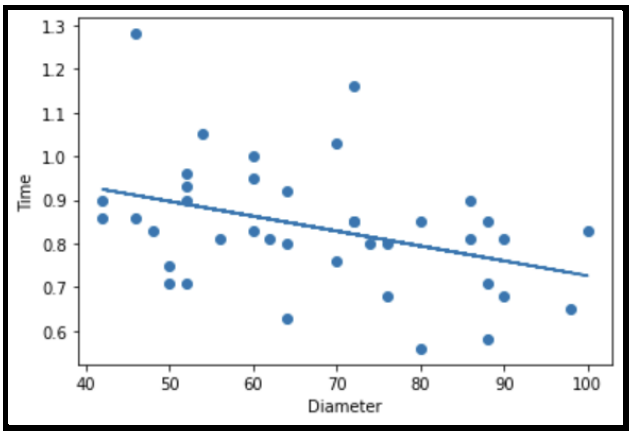
Using Mouse:



The experiment values of selection time for various random size targets at random distances are shown in the table below, along with the Index of Difficulty. The index of difficulty is defined as log 2 (2A / W) (ID). It describes how challenging the motor tasks are.

SNo	Radius	Distance	Index of Difficulty	Response Time
1	25	880.6	5.178873958	0.75
2	36	415.54	3.648784984	1.16
3	26	334.79	3.794575824	0.71
4	44	785.67	4.236962192	0.71
5	23	376.82	4.119644875	0.86
6	35	787.21	4.554080091	0.76
7	26	891.77	5.14154912	0.96
8	32	1258.54	5.333759143	0.92
9	40	621.7	4.048105374	0.85
10	28	345.28	3.73675948	0.81
11	44	368.14	3.227559061	0.85
12	31	866.12	4.854960854	0.81

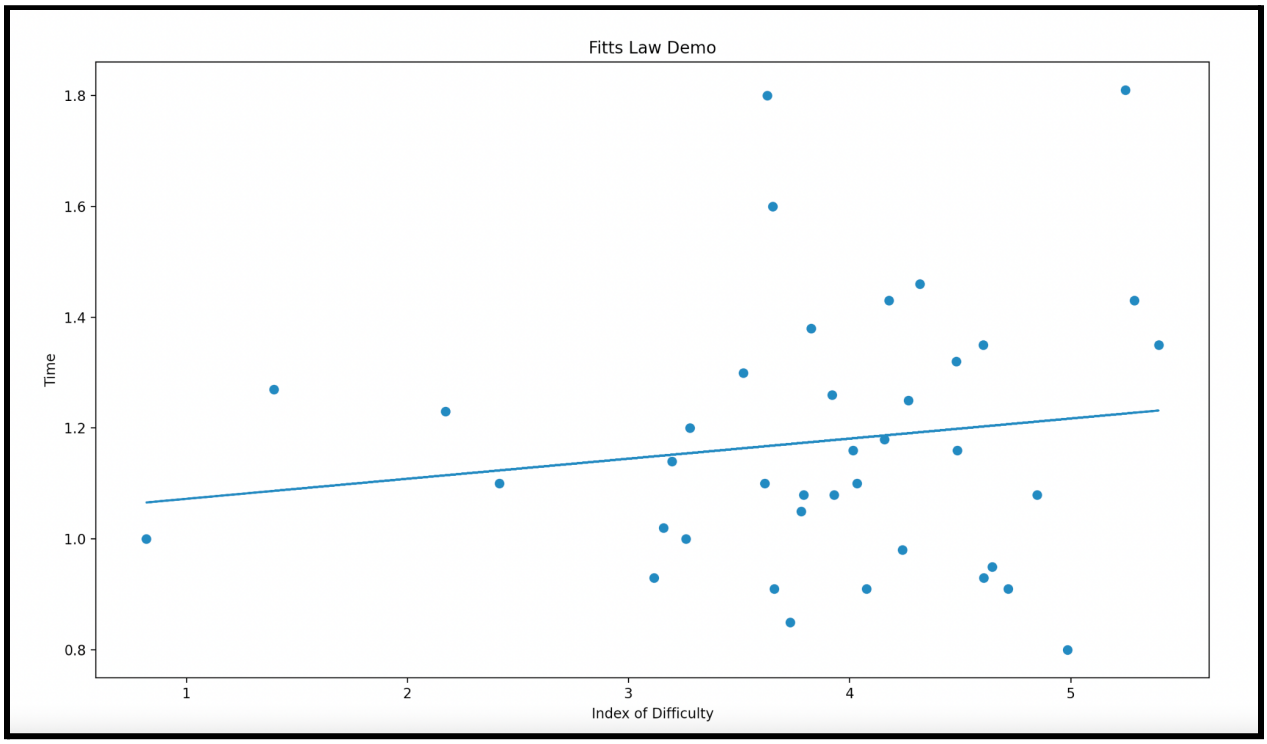
13	43	950.61	4.530271128	0.81
14	36	452.22	3.761462585	0.85
15	35	545.75	4.052490422	1.03
16	50	210.29	2.380119886	0.83
17	25	99.96	2.321466359	0.71
18	40	486.79	3.719156054	0.56
19	36	429.87	3.693858618	0.85
20	24	599.22	4.698635221	0.83
21	37	911.18	4.679563787	0.8
22	30	625.99	4.450639417	0.95
23	21	443.8	4.468148836	0.86
24	38	172.93	2.472692977	0.8
25	43	173.66	2.333024261	0.9
26	32	347.38	3.567499815	0.63
27	49	691.79	3.918210969	0.65
28	30	235.05	3.143230135	0.83
29	38	85.98	1.706036085	0.68
30	44	1356.54	4.992335854	0.58
31	27	1104.62	5.389286362	1.05
32	45	880.15	4.361690391	0.81
33	32	61.47	1.546431489	0.8
34	45	412.98	3.347287691	0.68
35	21	787.12	5.266108306	0.9
36	30	401.44	3.846125533	1
37	26	1117.43	5.458712614	0.9
38	26	1206.17	5.566545882	0.93
39	23	1212.8	5.747667607	1.28



Also we can see that as the diameter of the circle increases, time taken decreases. This is because of the small error rate for clicking on bigger circles.

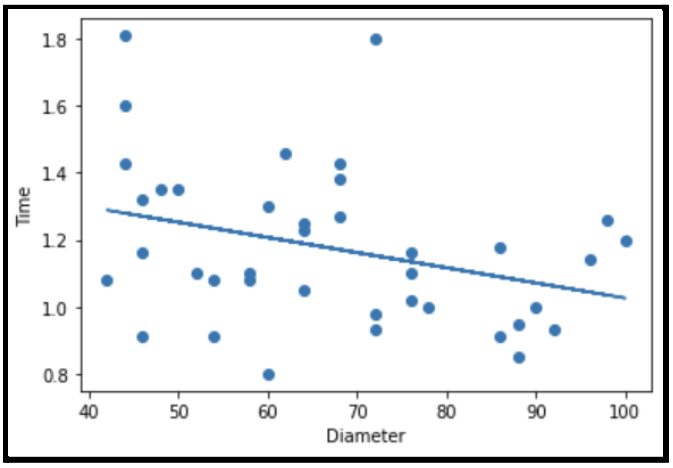
Even from the mathematical formula according to Fitts's law, time = a + b $\log_2$ (2A / W) Time $\propto$ A/W, where A is distance from the starting point to the centre of the target Time $\propto$ 1/W

Using trackpad:



SNo	Radius	Distance	Index of Difficulty	Response Time
1	31	587.18	4.317686859	1.46
2	23	491.21	4.482651901	1.32
3	38	576.42	4.015153854	1.16
4	38	584.14	4.033167943	1.1

5	43	724.52	4.15779578	1.18
6	30	313.64	3.517863571	1.3
7	46	352.5	3.114873958	0.93
8	39	334.57	3.259832573	1
9	32	407.57	3.779949118	1.05
10	38	301.33	3.15861766	1.02
11	36	643.19	4.237746406	0.98
12	36	408.59	3.626406687	1.8
13	24	987.41	5.397189732	1.35
14	27	384.62	3.93028177	1.08
15	26	292.74	3.615796552	1.1
16	23	492.74	4.486938177	1.16
17	34	55.44	1.395385442	1.27
18	30	920.15	4.985120884	0.8
19	29	372.55	3.791454834	1.08
20	22	254.5	3.651704052	1.6
21	36	841.43	4.607215222	0.93
22	21	583.76	4.847901487	1.08
23	22	814.1	5.248100074	1.81
24	34	448.04	3.825546216	1.38
25	43	682.14	4.075850993	0.91
26	48	391.85	3.195905301	1.14
27	45	34.37	0.818668804	1
28	23	581.6	4.716275213	0.91
29	49	693.22	3.920993222	1.26
30	32	112.15	2.171427027	1.23
31	44	540.27	3.731059786	0.85
32	29	125.72	2.415534895	1.1
33	27	314.08	3.659078849	0.91
34	44	1056.32	4.644275822	0.95
35	34	1293.84	5.287402761	1.43
36	22	376.02	4.177265497	1.43
37	25	583.28	4.60473557	1.35
38	50	434.37	3.276109513	1.2
39	32	583.14	4.264770981	1.25



Same trend can also be observed using a trackpad.

Analysis

Slope of line

MT = a + b log 2 (2A / W) = a+b ID, where ID is index of difficulty and b is inherent speed of the device (slope of line for selection time and ID).

For mouse click:

slope : 0.064629

For trackpad:

slope: 0.0529394

Response time increases with increase in target distance and decrease in target diameter. Response time therefore increases with increase in index of difficulty.

Hence, Fitts' law is verified.

Some notable observations:

- The selection time grows as the target's distance increases (as the distance, longer the cursor should move, thus increases time).
- The selection time lowers as the target size (i.e., diameter of the target) increases; the larger the size, the smaller the error on clicking larger circles.
- Overall, selection time increases as the index of difficulty (target distance/width) increases. This may be seen in the two graphs above.
- When a laptop's touchpad is used instead of a mouse, the selection time increases. This is due to the fact that navigating with a touchpad takes more time for most individuals.
- When a laptop's touchpad is used instead of a mouse, the slope of the line decreases, suggesting a decline in device speed as the touchpad consumes more time.