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Fitts Law Experiment

Project Source: *https://unaizafaiz@bitbucket.org/unaizafaiz/fittslaw.git*

Introduction to Fitts Law

Fitts Law is a scientific law that predicts that the time required to rapidly move to a target area is a function of the ratio between the distance to the target and the width of the target.[1] It describes the relationship between movement time, target width and amplitude in rapid aimed movements.

The formulation of Fitts Law's Index of difficulty most commonly used in Human Computer Interaction is known as Shannon's formula. It describes how the movement from start point to the target width and the distance between the two effects the Index of Difficulty (ID) of the task and is given as:

$$ID = log_2\left(\frac{A}{W} + 1\right) \qquad \text{---------- (1)}$$

Where A is the amplitude or distance of the task, W is the target's width and ID is the Index of Difficulty.

Experiment

In our experiment, a Java application was build to measure the movement time between targets for a range of distances. The movement between the targets is setup in accordance with the tapping task described in the ISO9241-9 standard (2002). This paradigm has the advantage of controlling for the effect of direction. We use circular targets with a clockwise motion alternating around the circle.

The test collects data for 2 target width and 3 amplitudes. These parameters are set randomly after each test round. Each round contains 20 circles and thus collects the movement time of 10 pairs for each case of target width and amplitude.

The target width and amplitudes set for this experiment are:
W = [25, 45] A = [100, 150, 200]

The movement time is captured for each iteration in each of the 6 cases, and the data is stored in a file called data_dump.log. This data was then analysed using R.

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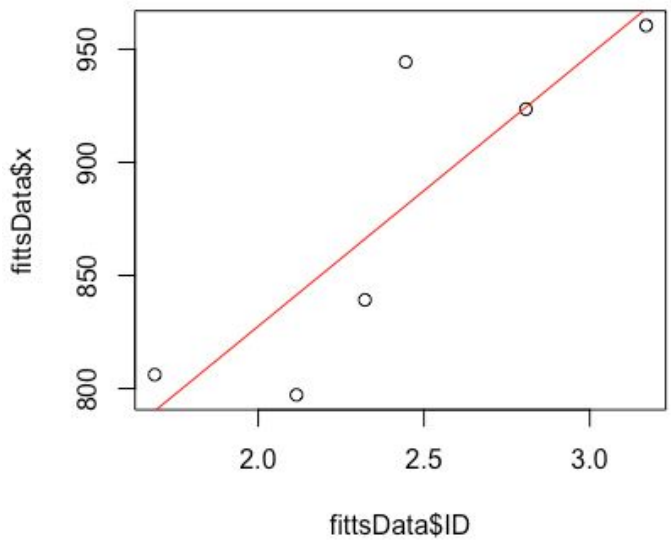
Data Analysis

For the purpose of this experiment we will be using Shannon's formula (as mentioned in equation 1) to calculate ID.

We first find the mean of the movement time for each group of A_i and W_j and hence get MT_{ij}, where $1 \le i \le 2$ and $1 \le j \le 3$. We calculate ID_{ij} for each case using the Shannon Formula. Hence for our target width and distance we get the values shown in the corresponding table, where the column x represents MT value.

	W	D	x	ID
1	25	100	839.20	2.321928
2	45	100	806.15	1.688056
3	25	150	923.50	2.807355
4	45	150	797.20	2.115477
5	25	200	960.40	3.169925
6	45	200	944.35	2.444785

Next, we plot a graph get MT vs ID with MT on y-axis and ID on x-axis.



Linear regression serves as a test to measure the goodness of fit , and the reasonableness of the results. [2] Least-squares linear regression is used to find the intercept (*a*) and slope (*b*) parameters of the Fitts' law equation,

$$MT = a + b \times ID$$

As a result, we get *a= 119.9476, b = 587.6431*. We use the regression coefficients to plot a line on our graph of MT vs ID. We observe, that as the target width decreases and distance increases the index of difficulty also increases. Thus, we see that the mean time for the movement is directly proportional to the ID.

Throughput vs ID

Moving on we calculate the throughput for our dataset. In Fitts's words, throughput is defined as "The average rate of information generated by a series of movements is the average information per movement divided by the time per movement" (1954, p. 390). It is metric used to quantify the pointing performance and is given by the formula -

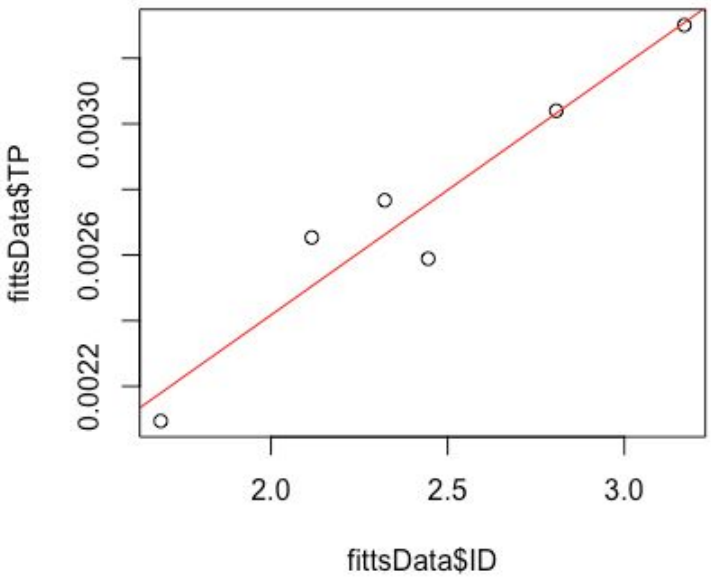
$$TP = \frac{1}{y}\sum_{i=1}^{y}\left(\frac{1}{x}\sum_{j=1}^{x}\frac{IDe_{ij}}{MT_{ij}}\right),$$

For the purpose of this experiment we calculate throughput as **TP = ID/MT**. We thus get the values of throughput as shown in the corresponding table.

	x	ID	TP
1	839.20	2.321928	0.002766835
2	806.15	1.688056	0.002093973
3	923.50	2.807355	0.003039908
4	797.20	2.115477	0.002653634
5	960.40	3.169925	0.003300630
6	944.35	2.444785	0.002588855

We calculate the regression coefficients for TP vs ID and hence get the values b = 0.0008933014 a = 0.0007619183. Plotting the graph and the regression line we get the corresponding graph.

From this we observe, that as the index of difficulty increases, the index of performance i.e the throughput also seems to increase.



References

Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. Journal of Experimental Psychology, 47(6), 381-391. doi:10.1037/h0055392

R. William Soukoreff and I. Scott MacKenzie. Towards a Standard for Pointing Device Evaluation: Perspectives on 27 Years of Fitts' Law Research in HCI

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