Project 1: Computational simulation of human display monitoring

Groups: Work in groups of 4-5

Assignment: Write a journal/conference style paper with Introduction/Background, Methods, Results, and Discussion. The paper should be 3 pages or less with 1 inch margins and 12 point font. Please keep figures readable. **Include at least 2 references**.

Due: September 15 at 11:59pm Mountain time on Canvas. Please upload a pdf of your report. Separately upload a text file(s) of your code (Matlab, Python, or otherwise).

Narrative:

On a future Mars base, Mark Watney is tasked with monitoring a set of displays and identifying any abnormalities. Use the N-SEEV (Noticing-Salience, Effort, Expectancy, Value) model to simulate his visual attention and performance at detecting an emergency notification.

In the N-SEEV model, the absolute probability of viewing a given area of interest (AOI) A next is estimated by:

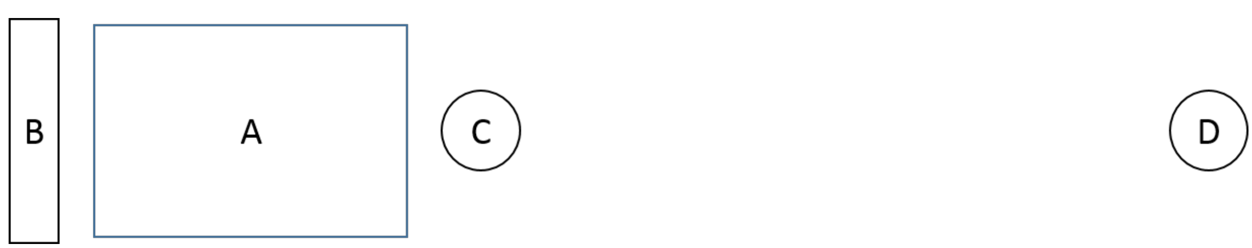
$p_{abs}(A) = S - Ef + Ex + V$

where S is the salience of AOI A, Ef is the effort required to transition from the current AOI to A, Ex is the expectancy of viewing A, and V is the value of viewing A. Note that for simplicity, as compared to the formal definition of the model, we assume the coefficients for each term are all 1 and thus they are not shown. The relative probability that a given AOI is viewed next can be computed by normalizing by the sum of the absolute probabilities: $p(A) = p_{abs}(A)/(p_{abs}(A) + p_{abs}(B) + p_{abs}(C) + \ldots)$

In the set of displays that Watney views there are four AOIs:

A. A primary display for an automated rover exploring the Martian surface. This is the main task and thus has S = 2, Ex = 4, V = 2. (Efforts defined below).
B. A monitor on the water levels in the habitat. While Watney loves growing crops, this is a pretty unimportant and static display and has S = 3, Ex = 2, V = 1
C. A communications display from Earth. Information is regularly provided, but is not particularly important and has S = 1, Ex = 3, V = 1
D. An emergency notification about incoming wind storms. It almost never goes off, but is essential to the crews' safety! It has S = 2, Ex = 1, V = 5

The displays are laid out as follows:



As a result, the Effort to transition from A to B is given by $Ef_{AB} = 1$, and equivalently:

$Ef_{AC} = 1$, $Ef_{AD} = 5$, $Ef_{BC} = 3$, $Ef_{BD} = 6$, $Ef_{CD} = 4.5$

In each case assume the Effort to transition is symmetric (e.g., $Ef_{AB} = Ef_{BA}$).

Assume the sequence of visual attention is determined by a fixation at a given display, followed by a saccadic eye movement to the next display, where the next display is determine by the N-SEEV model above. Each fixation time (in seconds) can be modeled as a random variable with a **log**normal distribution with μ=0 and σ=0.5. The duration (in seconds) of each saccadic eye movement can be assumed to be normally distributed with μ=0.03 and σ=0.003 (assume the saccadic eye movements, on average, take the same duration between any two displays).

1. Implement a computational simulation of a sequence in the scan pattern and graphically depict the eye position as a function of time for 10 fixations. Start each scan pattern at display A.
2. Perform Monte Carlo simulations (e.g., 1,000 simulations) of scan sequences of 100 total display fixations. What fraction of the time is spent viewing each display? Note that the total should not add up to 100% of the total time since there are saccades between each fixation in which no display is viewed.
3. In the next set of simulations, at 10seconds, in display D the wind alert goes off. Further assume that for each fixation of display D there is an 80% chance of detecting the wind alert (i.e., N=noticing). The alternative is the wind alert is missed and the scan pattern continues. Ignore the possibility of false alarms. If the wind alert is detected, assume the time instant within the fixation at which it is detected is uniformly distributed across the fixation time of that view of display D. Perform Monte Carlo simulations (e.g., 1,000 simulations) to calculate the distribution of detection times of the wind alert, after it goes off at 10 seconds. The time would include the time required from 10 seconds until display D is viewed, the time while viewing display D until it is detected, and if it is not detected the time of the subsequent scan pattern sequence(s) until it is detected in display D. If viewing display D at 10 seconds, assume there is an 80% chance of detecting the alert during that fixation, but if detected assume the time of detection is uniformly distributed just from 10 seconds until the end of that fixation. Show a histogram of these response times and provide the median and 5^{th} and 95^{th} percentiles.
4. After Mark Watney failed to detect the wind alert quickly enough and tragically perished, a smart engineer at NASA decided it was poor human-centered engineering design to have display D have such low salience and expect Watney to detect warnings in it. To increase salience, an auditory warning is provided concurrently when the wind alert occurs at 10 seconds that says “view display D”. This has been shown to increase the salience of display D to S = 5. Repeat the simulations in #3 and compare the distributions (including median, 5^{th} and 95^{th} percentiles).
5. Another even smarter engineer at CU-Boulder realized that in the operational environment it might be hard to hear an auditory warning when the wind is very high. Instead, she thought it would be better to reposition display D, in order to reduce the required Effort. How could D be repositioned (i.e., what set of Effort values for D) could be used in order to produce a similar median as that in #4? Which design change do you feel is preferable and why?