Discover User-App Interactions & Solutions to Reducing the Initial User-CPU Latency

Thy Nguyen Milon Chakkalakal Pranav Thaenraj

Advisors: Jamel Tayeb, Bijan Arbab, Sruti Sahani, Oumaima Makhlouk, Praveen Polasam, Chansik Im

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Abstract

Some block contents, followed by a diagram, followed by a dummy paragraph.

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Methodology of Data Collection

We write the ***input libraries (ILs)*** using the software development kit ***XLSDK User Guide***, along with the *Environment Server (ESRV)* toolchain and the ***Intel® System Usage Report (SUR)*** framework to anonymously gather and analyze data usage from multiple devices. The ILs include:

- **Mouse Input IL** to capture the (X, Y) positions of the mouse in pixels (with or without noise)
- **User Wait IL** to retrieve the cursor type (e.g. loading or working smoothly) and its timestamp
- **Mouse Hook IL** to track the UI objects clicked by the mouse
- **Foreground Window IL** to log the window's details detected by mouse clicks or time ticks
- **Desktop Mapper IL** to map all the open app windows in the z-order and store the relative position of an app on the screen as well as their individual size

We mainly focus on the data collected from the *Foreground Window IL* for further exploration.

Data Preprocessing

Exploratory Data Analysis

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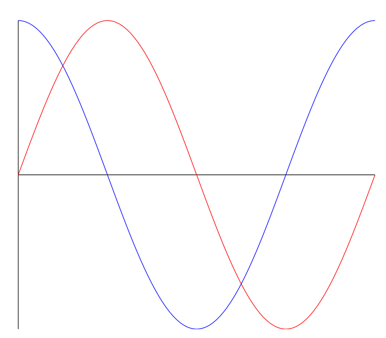

Figure 1. Another figure caption.

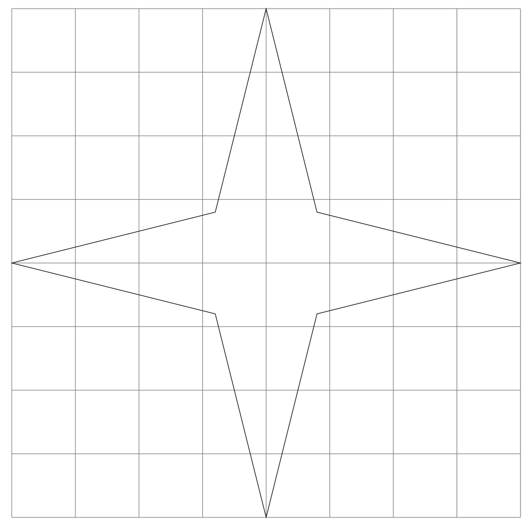

Figure 2. A figure caption.

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2. **Cras vehicula blandit urna ut maximus**. Aliquam blandit nec massa ac sollicitudin. Curabitur cursus, metus nec imperdiet bibendum, velit lectus faucibus dolor, quis gravida metus mauris gravida turpis.
3. **Vestibulum et massa diam**. Phasellus fermentum augue non nulla accumsan, non rhoncus lectus condimentum.

Methodology of Predictive Tasks

Hidden Markov Model (HMM)

- **Problem Statement**: Predict the likelihood of using an app *given* the former sequence of application usage
- **Basic Idea**: Utilize the conditional probability $P(A|B) = \frac{P(A \cap B)}{P(B)}$
- **HMM Assumptions**:

  1. **Markov Chain** Only the *current* state plays the most crucial role in predicting the future in the sequence; other states before that will not influence the future states

  $$P(q_i = a | q_1 q_2 ... q_{i-1}) = P(q_i = a | q_{i-1})$$

  where q_k are the states for $k \in \{1, 2, ..., i\}$, e.g. hidden states *chrome.exe* and *explorer.exe*

  2. **Output Independence** The probability of observing an event o_i only relies on the state q_i that *directly* produced o_i.

  $$P(o_i | q_1, ...q_i, ..., q_T, o_1, ..., o_i, ..., o_T) = P(o_i | q_i)$$

  where $o_1 o_2 ... o_T$ is a sequence of T observations and $q_1, q_2, ..., q_T$ are T states
- **Transition Matrix**:
- **Emission Matrix**: contains the emission probabilities, i.e. the likelihood of moving from one executable file to another app/tab.

  P("chrome.exe" -> "Spotify") = P("Spotify" | "chrome.exe")

Recurrent Neural Network (RNN)

- **Problem Statement 1**:
- **Problem Statement 2**: Predict the use time of an app/tab using the past *time-series* data

three main characteristics of RNNs. A looping mechanism, where the current prediction is impacted by the former predictions. An analogy of this is how our brain recognizes the patterns of the alphabetical order "ABCD..." by using the sequential information of a text. RNNs share parameters (i.e. the weight matrices W's) across the timestamps and across the positions. Hence, RNNs with more parameters will take more computational costs in training [15]. Thirdly, RNNs can easily face the gradient problems of vanishing or exploding. More specifically, the vanishing problem means the parameter update step will become insignificant once the gradient diminishes, whereas the update step becomes highly large when there exists a fast increase in the gradient [15]

Prediction Results

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First column	Second column	Third column	Fourth
Foo	13.37	384,394	α
Bar	2.17	1,392	β
Baz	3.14	83,742	δ
Qux	7.59	974	γ

Table 1. A table caption.

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Conclusion

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Future Directions

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References

[1] Claude E. Shannon.
A mathematical theory of communication.
Bell System Technical Journal, 27(3):379–423, 1948.