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

Abstract

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

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Morbi ultricies eget libero ac ullamcorper. Integer et euismod ante. Aenean vestibulum lobortis augue, ut lobortis turpis rhoncus sed. Proin feugiat nibh a lacinia dignissim. Proin scelerisque, risus eget tempor fermentum, ex turpis condimentum urna, quis malesuada sapien arcu eu purus.

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

Et rutrum ex euismod vel. Pellentesque ultricies, velit in fermentum vestibulum, lectus nisi pretium nibh, sit amet aliquam lectus augue vel velit. Suspendisse rhoncus massa porttitor augue feugiat molestie. Sed molestie ut orci nec malesuada. Sed ultricies feugiat est fringilla posuere.

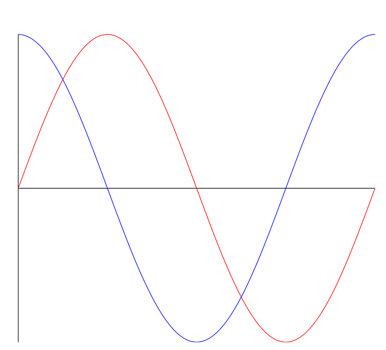

Figure 1. Another figure caption.

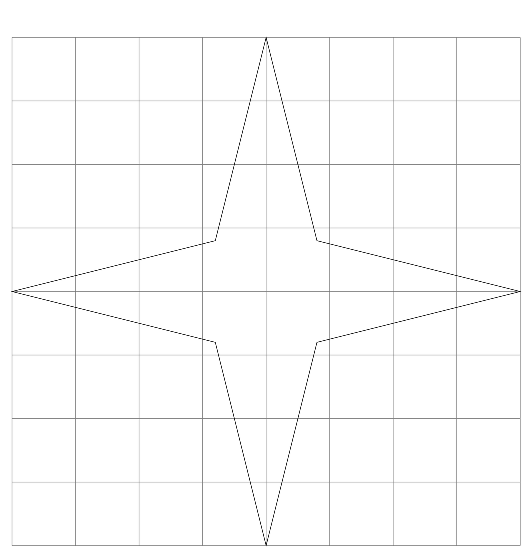

Figure 2. A figure caption.

1. **Morbi mauris purus**, egestas at vehicula et, convallis accumsan orci. Orci varius natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus.
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 <u>*current*</u> 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 <u>*directly*</u> 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
- **Why RNNs?**
  1. **A Looping Mechanism** The current prediction is impacted by the former predictions
  2. **Parameter Sharing** Weight matrices are shared across the timestamps / positions -> internal memory, weighting the importance of data
  3. **Gradient Vanishing/Exploding Problem** The parameter update steps become insignificant/significant depending on the gradients
  » But overall, robust to trends/seasonality/temporal features in noisy data
- **Feature Engineering**:
- **Experiments with RNNs**:
  1. **Vanilla RNN**:
  2. **LSTM**:
  3. **GRU**:

Prediction Results

Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos himenaeos. Phasellus libero enim, gravida sed erat sit amet, scelerisque congue diam. Fusce dapibus dui ut augue pulvinar iaculis.

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.

Donec quis posuere ligula. Nunc feugiat elit a mi malesuada consequat. Sed imperdiet augue ac nibh aliquet tristique. Aenean eu tortor vulputate, eleifend lorem in, dictum urna. Proin auctor ante in augue tincidunt tempor. Proin pellentesque vulputate odio, ac gravida nulla posuere efficitur. Aenean at velit vel dolor blandit molestie. Mauris laoreet commodo quam, non luctus nibh ullamcorper in. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos himenaeos.

Nulla varius finibus volutpat. Mauris molestie lorem tincidunt, iaculis libero at, gravida ante. Phasellus at felis eu neque suscipit suscipit. Integer ullamcorper, dui nec pretium ornare, urna dolor consequat libero, in feugiat elit lorem euismod lacus. Pellentesque sit amet dolor mollis, auctor urna non, tempus sem.

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

Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos himenaeos. Phasellus libero enim, gravida sed erat sit amet, scelerisque congue diam. Fusce dapibus dui ut augue pulvinar iaculis.

Donec quis posuere ligula. Nunc feugiat elit a mi malesuada consequat. Sed imperdiet augue ac nibh aliquet tristique. Aenean eu tortor vulputate, eleifend lorem in, dictum urna. Proin auctor ante in augue tincidunt tempor. Proin pellentesque vulputate odio, ac gravida nulla posuere efficitur. Aenean at velit vel dolor blandit molestie. Mauris laoreet commodo quam, non luctus nibh ullamcorper in. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos himenaeos.

Nulla varius finibus volutpat. Mauris molestie lorem tincidunt, iaculis libero at, gravida ante. Phasellus at felis eu neque suscipit suscipit. Integer ullamcorper, dui nec pretium ornare, urna dolor consequat libero, in feugiat elit lorem euismod lacus. Pellentesque sit amet dolor mollis, auctor urna non, tempus sem.

Conclusion

Nulla eget sem quam. Ut aliquam volutpat nisi vestibulum convallis. Nunc a lectus et eros facilisis hendrerit eu non urna. Interdum et malesuada fames ac ante *ipsum primis* in faucibus. Etiam sit amet velit eget sem euismod tristique. Praesent enim erat, porta vel mattis sed, pharetra sed ipsum. Morbi commodo condimentum massa, *tempus venenatis* massa hendrerit quis. Maecenas sed porta est. Praesent mollis interdum lectus, sit amet sollicitudin risus tincidunt non.

Etiam sit amet tempus lorem, aliquet condimentum velit. Donec et nibh consequat, sagittis ex eget, dictum orci. Etiam quis semper ante. Ut eu mauris purus. Proin nec consectetur ligula. Mauris pretium molestie ullamcorper. Integer nisi neque, aliquet et odio non, sagittis porta justo.

- **Sed consequat** id ante vel efficitur. Praesent congue massa sed est scelerisque, elementum mollis augue iaculis.
  - In sed est finibus, vulputate nunc gravida, pulvinar lorem. In maximus nunc dolor, sed auctor eros porttitor quis.
  - Fusce ornare dignissim nisi. Nam sit amet risus vel lacus tempor tincidunt eu a arcu.
  - Donec rhoncus vestibulum erat, quis aliquam leo gravida egestas.
- **Sed luctus, elit sit amet** dictum maximus, diam dolor faucibus purus, sed lobortis justo erat id turpis.
- **Pellentesque facilisis dolor in leo** bibendum congue. Maecenas congue finibus justo, vitae eleifend urna facilisis at.

Etiam sit amet tempus lorem, aliquet condimentum velit. Donec et nibh consequat, sagittis ex eget, dictum orci. Etiam quis semper ante. Ut eu mauris purus. Proin nec consectetur ligula. Mauris pretium molestie ullamcorper. Integer nisi neque, aliquet et odio non, sagittis porta justo.

Future Directions

......

References

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