

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

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## Abstract

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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.

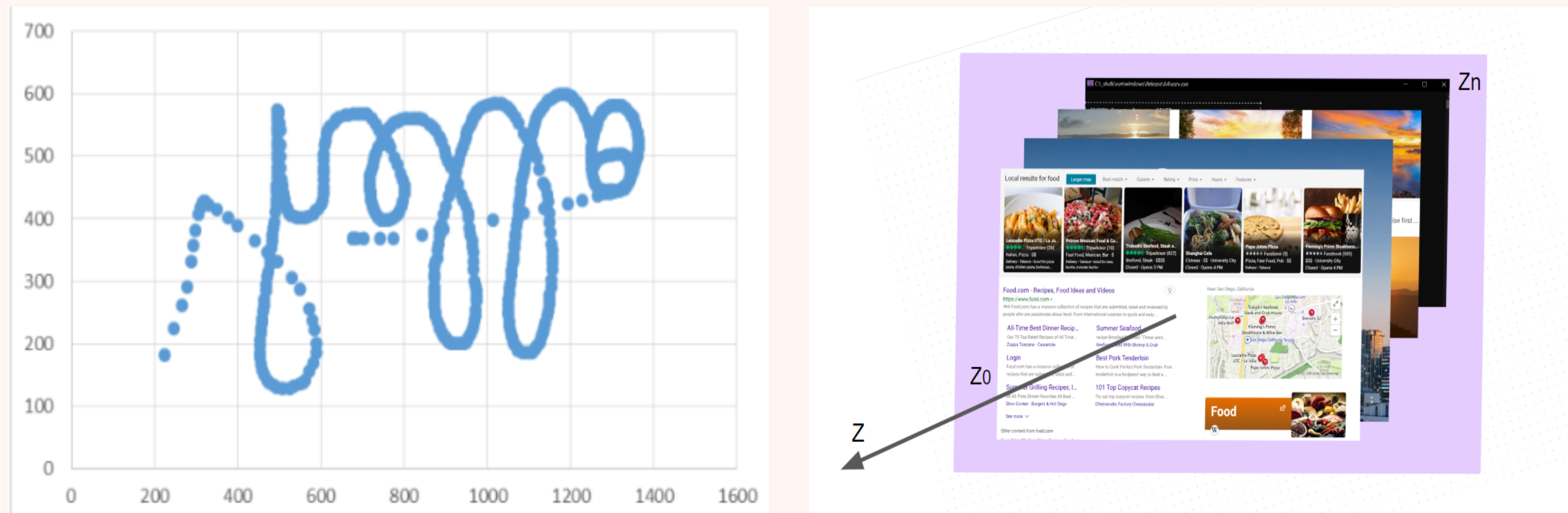


Figure 1. Mouse Movement, Foreground Window, and Z-axis

## Data Preprocessing

## Exploratory Data Analysis

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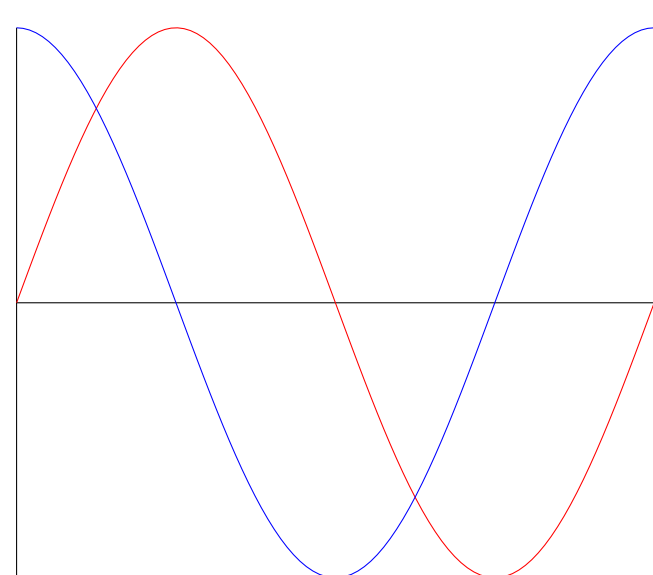


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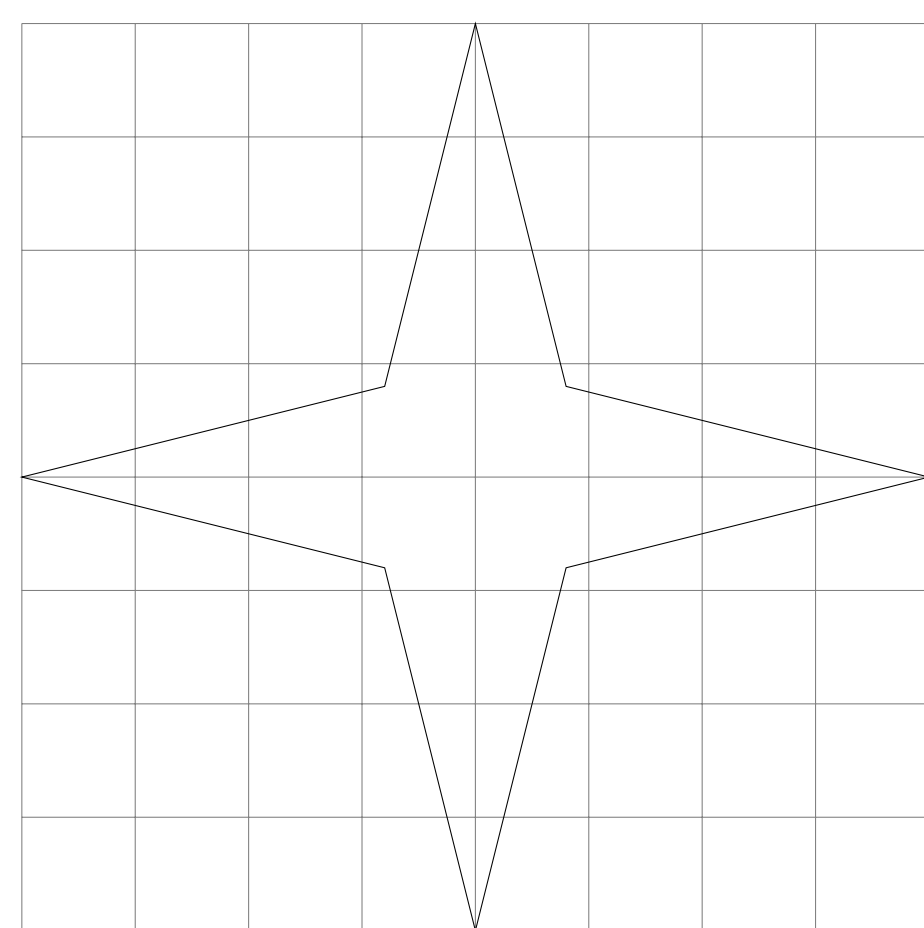


Figure 3. A figure caption.

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<https://www.example.com>

## 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

$$P(q_i = a|q_1q_2...q_{i-1}) = P(q_i = a|q_{i-1})$$

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  $o_i$ .

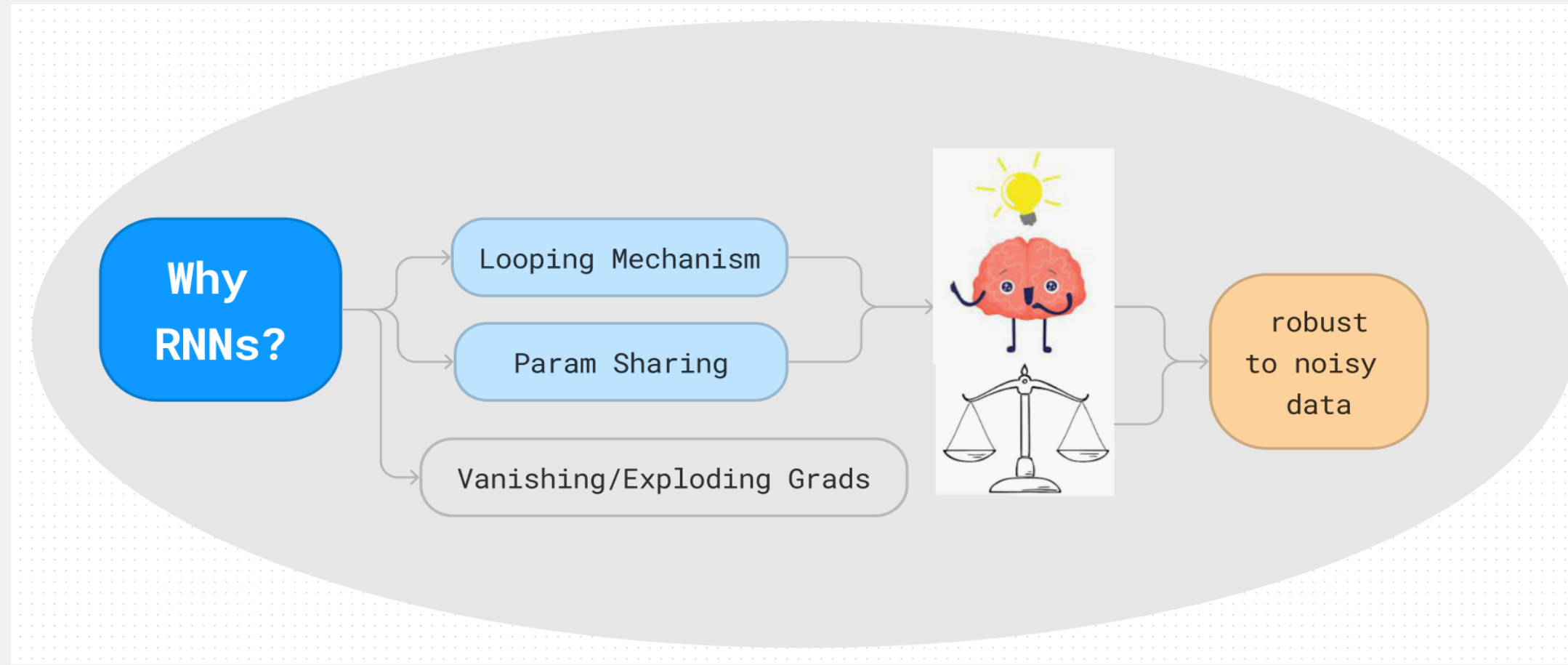
$$P(o_i|q_1, ..., q_i, ..., q_T, o_1, ..., o_i, ..., o_T) = P(o_i|q_i)$$

where  $o_1o_2...o_T$  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.  
 $P("chrome.exe" \rightarrow "Spotify") = P("Spotify" | "chrome.exe")$

### Recurrent Neural Network (RNN)

- **Problem Statement:** Predict the (total) time usage of an app/tab/recorded process using the past *time-series* data



- **Feature Engineering:**
  1. **Example 1:**
  2. **Example 2:**
  3. **Example:**
- **Experiments with RNNs:**
  1. **Vanilla RNN:**
  2. **LSTM:**
  3. **GRU:**

## Prediction Results

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First column	Second column	Third column	Fourth
Foo	13.37	384,394	$\alpha$
Bar	2.17	1,392	$\beta$
Baz	3.14	83,742	$\delta$
Qux	7.59	974	$\gamma$

Table 1. A table caption.

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## Conclusion

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## Future Directions

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## References

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