Embedding Human-System Integration Metrics in Agile Software Evaluation Environments:

The Value of Opportunistic Behavioral Data Collection

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Human System Integration Metrics Development

**Our methods for gauging human system integration can affect transitional value of technology**

- The laboratory’s very purpose is to remove measurement from the wild.
- Experiments force specific ways of interacting with stimuli.
- Questionnaires, Surveys, and Interviews include both subjective and retrospective biases.
- Physiological methods provide convoluted information that is difficult to directly apply to relevant use cases.

**Any tool that people use to perform a task can be instrumented to collect data on how they perform that task within their respective environments**

- We’re turning software applications, mobile phones, games and simulators into “sensors” to understand how people behave not just observe what they do.
- From models of how people behave we develop intuitive psychometrics.
**Software as a Sensor™ Assessment**

**Process**
1. *Instrument* Software
2. Let end-users *use* Software
3. *Model* log data
4. **Visualize** models and derivative metrics
5. **Track** changes across versions

**Value**
1. Non-invasive, streaming data source
2. Collect Data in actual use cases
3. Generalized Models of “how”
4. Assessment tied to technology
5. Agile process
Metrics Approach

Data Collection

- Instrumentation
- Activity Sequences

Modeling

- Beta Process HMM
- Sub-sequences

Proxies for Cognitive Load based on *how* software is used.

- Integrated Use
- Strategy Shifts
- Fixedness in Use
- Specialized Workflows
- Workflow Variety
The Beta-Process HMM (BP-HMM):

- An unsupervised-learning method that identifies a global library of states (behaviors) from an ensemble of related time-series, and assigns a subset to each individual sequence.

Example 3-state model of an ensemble of sequences encoding 4-categories of activities.

The canonical ‘modes’ of behavior are encoded in the parameters of the hidden-state categorical distributions.
Beta-Process HMM Metrics

- Activity distributions for each state capture the way different components of the application were used together in time.
- Metrics derived from the BP-HMM model parameters allow for comparison across applications.
Modeling Workflow: Subsequences

- Sub-sequences are atomic-level workflows describing the patterns of software activities users integrate to perform tasks.

- For each user session, we extract overlapping sequences of lengths 3-6, creating a library of short activity kernels.

<table>
<thead>
<tr>
<th>Sequence of activity logs from a Neon session</th>
</tr>
</thead>
<tbody>
<tr>
<td>59, 25, 50, 25, 59, 25, 50, 43, 36, 50, 25, 25, 24, 24, 25, 25, 24, 9, 49, 9, 14, 49, 8, 49, 25, 8, 25, 43, 36, 49, 9, 44, 49, 5, 49, 39, 49, 9, 59, 8, 50, 43, 36, 49, 8, 59, 25, 43, 36, 49, 9, 50, 9, 43, 36, 49, 39, 49, 9, 38, 49, 8, 49, 9, 2, 4, 1, 62, 60, 1, 63, 1, 14, 9, 49, 9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extracted Sub-Sequences (length 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>[59, 25, 50], [25, 50, 25], [50, 25, 59], [25, 59, 25], [59, 25, 50], [25, 50, 43], [50, 43, 36], [43, 36, 50], [43, 50, 25], [50, 25, 25], [25, 25, 24], [25, 24, 24], [24, 24, 25], [24, 25, 25], [25, 25, 24], [25, 24, 9], [24, 9, 49], [9, 49, 9], [49, 9, 14], [9, 14, 49], [14, 49, 8], [49, 8, 49], [8, 49, 25], [49, 25, 8], [25, 8, 25], [8, 25, 43], [25, 43, 36], [43, 36, 49], [36, 49, 9], [49, 9, 44], [9, 44, 49], [44, 49, 5], etc....</td>
</tr>
</tbody>
</table>

- Screenshot of Neon with sample length-3 activity sub-sequences overlaid
Using software as a sensor proves to be better than the current state-of-the-art in predicting **performance**.
Data Collection at Scale

• Large scale data collection on a variety of applications provides data to move from metrics to assessment.
  • Assessments and labels applied to metrics based on large population distributions
    • Normalized Percentile Ranks
    • Good OR Bad

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