Human-Centered Approaches to Software Engineering Research

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Programmers and Work

At least 55 million in the U.S. write code to get their work done (end-user programmers)

At least 3 million in the US have a career in programming (professional programmers)

By 2012, 30% of new jobs in the US may require programming skills

[Scaffidi 2005] [US Bureau of Labor and Statistics 2005]
Programmers are People!
My Interests

I’m fascinated by the way that software is changing the world and changing people’s work...

What can we do to help people improve software quality and their own productivity?

I’m interested in building interactive tools...
Process

Study software development

Social Science

Cognitive Science

Computer Science

Communication Design

Questions

Insights

Design new tools

Andrew Ko • July 24th, 2006
Projects

Seven tools and the studies that inspired them.
Why does bug fixing take so long?

Whyline

2003 2004 2005 2006
Debugging Event-based Code

Observed 15 students creating games with Alice
Interviewed 7 designers creating UIs with Flash
Helped 40 students learn Visual Basic.NET
People's guesses about why a program has failed tend to be wrong, so they spend most of their time testing false hypotheses.

People formed false hypotheses, because tools require them to form hypotheses prematurely.
Let people ask *why did* and *why didn’t* questions about their programs’ *output*, which they can reason about accurately.

Use program slicing and other techniques to determine what code they should inspect.
Whyline - a Workspace that Helps You Link Instructions, Numbers and Events
Whyline: a Workspace that Helps You Link Instructions, Numbers and Events

Debugging time reduced by a factor of 7.8 (p < .02)

Correctly completed 40% more tasks (p < .02)
What influences a spreadsheet’s correctness, but is not formally specified in the spreadsheet?

*Slate*

with Michael Coblenz
Spreadsheet Errors

Studied data and formulas in spreadsheets from a corpus of public spreadsheets.

- total weight of fruit shipped
- average grade of students in afternoon English
- dollars spent on groceries in January
People encode values with both **units** and **labels**.

Many formula errors computed valid *units*, but *invalid* labels.

\[ 25.0 \text{ kg of apples} + 10.0 \text{ kg of oranges} = 35.0 \text{ kg of ??} \]
Introduce the concept of labels. Define a type system to allow their propagation.

We defined semantics for adding, subtracting, multiplying, and dividing labels.

Users can compare the labels shown to the labels expected.
**Slate**  a Spreadsheet Language that Accentuates Type Errors

![Slate Spreadsheet Image]

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Fruit Prices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 $0.45 / lb.</td>
<td>$0.50 / lb.</td>
<td></td>
</tr>
<tr>
<td>3 Fruit Sold</td>
<td>Revenue</td>
<td></td>
</tr>
<tr>
<td>4 312 lb.</td>
<td>$140.40</td>
<td></td>
</tr>
<tr>
<td>5 399 lb.</td>
<td>$179.55</td>
<td></td>
</tr>
</tbody>
</table>
**Slate** a Spreadsheet Language that Accentuates Type Errors

![Spreadsheet Image]

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fruit Prices</td>
<td>$0.45 / lb. (apples)</td>
<td>$0.50 / lb. (oranges)</td>
</tr>
<tr>
<td>2</td>
<td>$0.45 / lb. (apples)</td>
<td>$0.50 / lb. (oranges)</td>
<td></td>
</tr>
<tr>
<td>3</td>
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</tr>
<tr>
<td>5</td>
<td>399 lb. (oranges)</td>
<td>$179.55 (apples, oranges)</td>
<td></td>
</tr>
</tbody>
</table>

- **A6 * B2**
- **A6 * A2**

strange label calls attention to discrepancy
Why are programs that manipulate structured data so large and difficult to maintain?
Software for Structured Data

Analyzed the source code for large interactive, incremental tools.

Alice

Eclipse
Languages like Java necessitate large amounts of boilerplate code to manage listeners, constraints, and event handlers, value restrictions.

```java
IWorkspace workspace = ResourcesPlugin.getWorkspace();
IResourceChangeListener listener = new IResourceChangeListener() {
    public void resourceChanged(IResourceChangeEvent event) {
        System.out.println("Something changed!");
    }
};
workspace.addResourceChangeListener(listener);

//... some time later one ...
workspace.removeResourceChangeListener(listener);
```
Create first class language features to simplify the expression of these common architectural patterns.

By building them into the runtime, the syntax required to express them is greatly simplified.
Citrus  a language for Creating Interactive Tools that Reshape and Utilize Structure

value constraints

\[
\text{top} \leftarrow ((\text{this previousView}).\text{bottom} + 5.0)
\]

value restrictions

\[
\text{has Int caretIndex} = 0
\begin{align*}
& \text{for which } (\text{caretIndex} \geq 0) \\
& \text{otherwise } 0 \\
& \text{for which } (\text{caretIndex} \leq (\text{text length})) \\
& \text{otherwise } (\text{text length})
\end{align*}
\]

event handlers

\[
\text{when event (editor FileSelected)} \\
\text{(do) } \\
\text{(event.ol}.d.@background \text{set nothing)} \\
\text{(event.new.@background \text{set Color.orange})}
\]

[Diagram of an editor window and files]
Projects

What questions do users of office applications have difficulty answering?

Crystal

with undergrad David Weitzman

2003  2004  2005  2006
Collected a corpus of *why* questions that office workers had about their office applications.

Why didn’t this get auto corrected?

Why did this get marked as misspelled?

Why is this whitespace here?
To answer these questions, users explored the user interface and online help for answers.
Allow users to click on objects in the application and select a why question about its behavior.

Maintain a causality graph as part of the undo history. Answers are all paths from a visible input to a visible output.

Why didn’t this get auto corrected?
The Crystal demo text editor allows multi-font typing, styles on paragraphs and other features copied from Microsoft Word.

I can type just like with any other text editor. Why is this bold?

Teh
In a user test, users with Crystal’s question asking features were able to resolve all of the problems we posed.

Users without question support took significantly longer on the simpler tasks and gave up on the more complex tasks.

Currently speaking with Microsoft developers about the potential for this technology in future versions of Office.
How do programmers utilize text as a medium for their work?
Source Code Editors

Screen captured expert Java programmers doing development and maintenance tasks

Analyzed open source code comments.
Source Code Editors

Programmers need most of the flexibility of text for their modifications, but...

Text is an limited medium for the type of information that developers want to embed in code.
Design code editor toolkit that supports rich media, embedded tools, and alternative views, while still supporting conventional text editing.

Represents code as trees of structures and tokens, but still allows code to be edited as text.
Barista: Basic Abstractions for Rapidly Implementing Structured Text-editing Applications

```java
public class FruitPainter {
    public void paintFruit(Shape shape) {
        int left = shape.getMinX();
        int top = shape.getMinY();
        int right = shape.getMaxX();
        int bottom = shape.getMaxY();

        if (shape.isRound()) {
            shape.setFillColor(Color.RED);
            shape.setFillRule(SolidFill);
            Image apple = loadImage("apple.png");
            paint(apple, 40);
        }
    }
}
```

```java
public class Distance {
    public static final double main(double x1, double y1, double x2, double y2) {
        return Math.sqrt(Math.pow(x2 - x1, 2) + Math.pow(y2 - y1, 2));
    }
}
```

```java
public class Alternatives {
    public double getLeftPosition() {
        return 0;
    }
}
```

```java
public class ImageTransformer {
    public void rotate(Image img, double degrees) {
    }
}
```
What are the major sources of effort when using an IDE to complete software maintenance tasks?

*Jasper*

with Michael Coblenz
Navigating Source Code

Fine-grained analysis of 10 Java programmers actions during debugging and enhancement tasks.
Navigating Source Code

People return to task-relevant code frequently, but to navigate to it, they have to use file tabs, scroll bars and lists.

35% of time was spent just with the mechanics of these navigations.
Design a user interface that allows all of the relevant code to be viewed in a single place.

This workspace would represent a task, and could hold any kind of relevant information, in addition to code fragments.
Jasper
Java Aid with Sets of Pertinent Elements for Recall
What are the information needs of bug fixing work at Microsoft?

Internship with Rob DeLine
Bug Fixing at Microsoft

Twenty 2-hour observations of Microsoft developers bug fixing.
Program understanding by reading and analyzing code is rare, because of its cost and risk of failure.

Configuring a workspace for the reproduction, testing, and debugging of a bug is extremely costly.

Developers need to know the behavior of code and its design rationale.
Whyline for Java
Conclusions

Software development is complex and social work.

Understanding this work and designing tools to support it is an interdisciplinary problem.
Questions?

http://www.cs.cmu.edu/~marmalade

Human-Computer Interaction Institute