Root Cause Analysis for HTML Presentation Failures using Search-Based Techniques

Sonal Mahajan, Bailan Li, William G.J. Halfond

Department of Computer Science
University of Southern California
What is a Presentation Failure?

Web page rendering ≠ expected appearance

Expected appearance (oracle)  Web page rendering

This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news! This is indeed a big news!
Difference 1: Alignment problem
Difference 2: Color problem

Expected appearance (oracle)  Web page rendering
Difference 3: Text style problem
Impact of Presentation Failures

1. Reduces usability of the web page
2. Gives a negative impression of service offered or product quality
3. Affects image and branding efforts

For the end user there is a low penalty for just moving on to the next web page
Presentation Failures

• Occur easily in modern web applications
  – Highly complex
  – Dynamic nature of HTML, CSS, JavaScript

• Difficult to debug
  – Each page has hundreds of HTML elements
  – Each HTML element may contain dozens of styling properties
Debugging Presentation Failures

1. **Detection:** determine whether a presentation failure has occurred

2. **Localization:** identify the faulty HTML element and visual property (CSS property or HTML attribute)
Related Approaches

• Manual debugging
  – Browser developer tools (e.g., Firebug)
  – Labor-intensive and error-prone

• Selenium, Sikuli, Cucumber, Crawljax
  – Require exhaustive specification of correctness invariants

• Cross-browser testing
  – Cannot report exact root cause – faulty visual property
  – Cannot be used if DOM has changed significantly

• Fighting Layout Bugs
  – Cannot report a root cause and application independent
# Debugging Presentation Failures

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Detection</strong>: determine whether a presentation failure has occurred</td>
<td>Prior Work (WebSee)</td>
</tr>
<tr>
<td>2. <strong>Localization</strong>: identify the faulty HTML element and visual property (CSS property or HTML attribute)</td>
<td>This Paper</td>
</tr>
</tbody>
</table>
Detection: WebSee

• **Input:** Test web page and its oracle
• **Output:** Prioritized list of potentially faulty HTML elements

Phases:

1. **Detection:** image processing techniques to find visual differences
2. **Analysis:** rendering-based analysis to identify potentially faulty elements.
3. **Prioritization:** rank HTML elements based on heuristics
Localization: Key Insight

Image processing techniques allow us to define this as a search problem

1. Correcting faulty element will cause rendering of page under test and oracle to match
2. Guide search by using a fitness function based on image processing (e.g., minimize number of difference pixels)
Our Approach

- **Input:** Test web page, oracle, and ranked potentially faulty HTML elements
- **Output:** Faulty HTML element and faulty property

**Mechanism:** Perform genetic algorithm based search over the visual properties of potentially faulty HTML elements
Genetic Algorithm

- **Population domain**: Possible values for a visual property
- **Initial population**: Generated randomly
- **Selection**: Linear ranking
- **Mutation**: Uniform mutation
- **Fitness function**: Minimize visual differences
- **Stopping criteria**: *web page = oracle*
Categorization of Visual Properties

1. Size and Position
2. Color
3. Predefined values
Category 1: Size and Position

- E.g., margin, padding, height, width
- Key commonality: numeric values over a continuous range

- Population: all integers
- Fitness function: minimize the number of difference pixels
Category 2: Color

- E.g., text color, background-color, border-color
- Color values:
  - 140 color names
  - 16 million colors (#000000 to #FFFFFF)

- Population:
  - Lookup expected color in oracle -> generally fails

- Fitness function
  - Minimize number of difference pixels -> useless
  - Use average color distance of difference pixels
Category 3: Predefined values

• E.g., font-style, display, font-family, border-style
• Set of discrete predefined values
  – font-style = \{italic, oblique, normal\}

• Exploration method
  – No notion of “closeness” to guide search
  – Use exhaustive exploration
  – Not very expensive
    • Max: 21 elements,
    • Avg: 5 elements
Example

Oracle

- Candidate root cause: `<div, padding>`
- Population domain: all integers
- Initial population: `{20, 50, 100, …, 0, 5}`

Test web page
Example

![Login Form]

- Username:
- Password:

Sign in

Forgot your password?
Example

![Login](image)
Example
Example
Example
Example

Login:

Username: 

Password: 

Sign in

Forgot Password?
Example

Match found!
Experiment

• Evaluate accuracy
• Compare results with random search
• Evaluated for Category 1 and 2 only

• **Subject application:** GMail homepage
• **Oracle:** GMail homepage screenshot
• **Test cases:** Seeded faults
Experiment Procedure

• Total 37 test cases
• Run random search and our approach five times on each test case
• Limit search space for experiment to run within 24 hours
• Terminate random approach once it exceeds time of genetic algorithm
## Experimental Results

<table>
<thead>
<tr>
<th>Category</th>
<th>GA</th>
<th>Random</th>
<th>Test #</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Numeric</td>
<td>100%</td>
<td>59%</td>
<td>30</td>
</tr>
<tr>
<td>2. Color</td>
<td>100%</td>
<td>37%</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>55%</strong></td>
<td><strong>37</strong></td>
</tr>
</tbody>
</table>

- **Conclusions**
  - Validates feasibility of our search-based approach
  - Outperforms random search

- **Threats to validity**
  - Restriction on the search space
  - Small sample of web applications and faults
Future Work

• Improve performance
  – Improve search space initialization
  – Prioritize visual properties
• Create a comprehensive search framework
• Handle multiple failures
• Improve fitness functions
• Evaluate larger set of web applications
Summary

1. Technique for automatic identification of faulty elements and properties

2. Analysis expressed as a search problem

3. Helpful in debugging presentation failures

4. No HTML/CSS expertise required

5. Better performance than random search
The End

Thank you
Usage Scenarios

1. Presentation Development Testing
2. Regression Debugging
Presentation Development Testing

• Front-end developers
  – Expected to convert image-based mockups to “pixel perfect” template pages

• Back-end developers
  – Change templates by adding dynamic content

• Both continuously test if the implemented page is consistent with the mockup

• Oracle is the mockup
Regression Debugging

• Changes to code after initial implementation
  – E.g.: Refactoring page from <table> based layout to <div> based layout

• Changes not intended to change appearance

• Test for presentation failures and debug to find responsible HTML elements

• Oracle is the previous correct version
Mockup Driven Development

• Mockups generated by graphic designers
• Front-end developers must create “pixel-perfect” template pages
• Cursory search for front-end developer job postings shows this is very common
Key Responsibilities / Performance Requirements:

- Generate pixel-perfect web pages from high fidelity mock ups created in Photoshop and Fireworks.

Required Skills:

- Strong command of programming (PHP, SQL and JavaScript with cool) and an eye for simplicity and user experience.
- Experience in front-end technologies (Web 2.0, CSS, HTML5, JavaScript).
- Experience and ability to effectively use your personal skills and frameworks (jQuery, Angular, React, etc.).
- Experience with Git and version control systems.
- Familiarity with SharePoint, Photoshop, Illustrator, Sketch, and other design tools is a plus.
- An established and extensive knowledge of technology and interactive design as embodied through your portfolio.
- You'll be working with interactive artists and designers to be trained. Expert level proficiency, look and feel proficiency.
- You'll learn to consider end user needs in the design process.
- You'll learn to consider end user needs in the design process.
- You're a team player with a passion for working with other designers and engineers.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
- You'll have the opportunity to work in an environment that's fast-paced, collaborative, and fun.
• Expert at coding semantic HTML markup
• Ability to develop pixel perfect sites that meet the design requirements
• Experience building responsive websites
Job Duties

- Gathering, interpreting requirements from clients and designers and translating them into CMS based websites with pixel-perfect fidelity to Photoshop comps.
Drupal Front End Developer
Promet Solutions Corporation - Chicago, IL

- Proficient in converting PSD compositions into HTML and CSS markup
- Must have high attention to detail, capable of pixel-perfect page construction that performs well across browsers.
Interpret existing site design and style guides by creating pixel perfect web pages from Photoshop files.
Code pixel-perfect, cross-browser compatible templates using HTML 5 and CSS, from designs provided by our internal design team or external agencies.
Be able to create pixel perfect sites/pages from approved creative designs, and also be able to offer feedback to the team when UI/UX elements need to be altered in order to adhere to development best practices.
Responsible for creating pixel perfect templates based on designer mock-ups, using HTML, CSS, and JavaScript
The Front-end Web Development Team for Sony Electronics in San Diego, CA, is currently looking for creative and talented Web Developer’s that will be responsible for translating visual designs into pixel perfect, standards-compliant web pages for the Sony Store Online e-commerce website.
Ability to develop pixel perfect implementations of Photoshop comps
Our new web developer will work closely with our Ecommerce UX, Design, and Development Teams to transform mock-ups into cross-platform pixel-perfect web interfaces--achieving well executed, high-performing, scalable, and easily maintained results.
Toaster Ltd is a specialist digital creative agency based in London. We are currently working on some amazing digital projects for clients such as Google, YouTube, Toyota and LavaNova. We work alongside Google Creative Lab to craft ideas, explore concepts and execute pixel-perfect sites for projects such as Google+ and Sync Sports. Life in a day, YouTube Specials Lab, Google Science Fair and R+I/Adv as well as projects making the world a better place.

We are looking for experienced Front End Developers, Full-time or Freelance, to work on exciting, ground-breaking projects, making the world a better place.

Interns
We are accepting applications from new graduates or undergraduates seeking experience. Email jobs@toasterltd.com to apply.

- Excellent eye for layout and ability to translate PSD files into pixel perfect HTML/CSS code

**Skills**

- Preference with SASS / LESS
- Knowledge of experience with CSS, JavaScript
- Experience with HTML5
- CSS and HTML5 drawing API proficiency
- JS libraries knowledge (especially Google Closure Libraries)

**How to apply**

We offer a competitive salary rate and the possibility to work remotely.

Please submit your application to jobs@toasterltd.com with 'Developer - London' in the subject line, along with a cover letter and any sample URLs that show off your code and prove you'll be able to hit the ground running.

**About Toaster Ltd.**

Toaster Ltd is a specialist digital creative agency with offices in London, Singapore and Hong Kong. We are a team of designers and digital experts, with a focus on creating, developing and producing high-quality digital experiences for clients.

We work with Google Creative Lab, and directly for other brands like Toyota, Red Bull and LavaNova. As well as helping other advertising agencies produce good stuff. Our work has been recognised at Cannes with a Gold Cyber Lion, by D&AD, the HAKA, The Fiasko Awards and The Thomson Awards.

**London**

10-14 Grape Street, London, EC2P 0BY
10 Grape Street, London, EC2P 0BY
Tel: 0207 240 9427

info@toasterltd.com

Toaster Ltd is registered in the United Kingdom Reg. No. 6742615.