LTAT.05.006: Software Testing


Spring 2022

Dietmar Pfahl
email: dietmar.pfahl@ut.ee
Lectures

- Lecture 1 (10.02) – Introduction to Software Testing
- Lecture 2 (17.02) – Basic Black-Box Testing Techniques: Boundary Value Analysis & Equivalence Class Partitioning
- Lecture 3 (03.03) – BBT advanced: Combinatorial Testing
- Lecture 4 (10.03) – Basic White-Box Testing Techniques: Control-Flow Coverage
- Lecture 5 (17.03) – BBT adv.: State-Transition, Metamorphic, Random Testing
- Lecture 6 (24.03) – Test Levels, Test Tools, Test Automation
- Lecture 7 (31.03) – BBT adv.: Exploratory Testing, Behaviour Testing
- Lecture 9 (14.04) – Security Testing of Mobile Applications
- Lecture 10 (21.04) – WBT adv.: Data-Flow Testing / Mutation Testing
- Lecture 12 (05.05) – Defect Estimation / Test Documentation, Organisation and Process Improvement (Test Maturity Model)
- Lecture 13 (12.05) – Exam Preparation
- Lecture 14 (19.05) – Advanced Topics (optional)
Structure of Lecture 8

• GUI Testing
  • GUITAR
  • TESTAR
• Visual Testing
  • Sikuli IDE
  • Lab 7
• Security Testing
• Usability Testing
• A/B Testing
Structure of Lecture 8

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GUITAR

Source: https://sourceforge.net/projects/guitar/
GUITAR

Source: https://sourceforge.net/projects/guitar/
GUITAR – GUI Ripping

• During ripping, the GUI application is executed automatically; the application’s windows are opened in a depth first manner.
  • For each GUI window, the Ripper first extracts structural information of that window and then executes widgets that invoke other GUI windows.
  • The depth-first traversal terminates when all GUI windows are covered.

• The Ripper extracts from the GUI all the widgets and their properties.
  • Properties of widgets include basic attributes (position, color, size, enabled status)
  • Properties also include information about widgets' events, such as:
    • whether a widget opens a modal or modeless window or a menu,
    • whether a widget closes a window, and
    • whether the widget is a button or an editable text-field.
GUITAR – GUI Ripping

GUI of an app with two windows

GUI tree with 2 nodes and subset of attributes
GUITAR

Source: https://sourceforge.net/projects/guitar/
GUITAR – Model Conversion

- EFG = Event Flow Graph
GUITAR

Source: https://sourceforge.net/projects/guitar/
GUITAR – Test Case Generation

Applies traversal algorithms for the EFG:

Defined length $L$ of event sequences

Example ($L=5$):

$e_1 \rightarrow e_2 \rightarrow e_3 \rightarrow e_4 \rightarrow e_5$
GUITAR

Source: https://sourceforge.net/projects/guitar/
## GUITAR – Test Case Execution & Evaluation

<table>
<thead>
<tr>
<th>Fault ID</th>
<th>Summary</th>
<th>Test case</th>
</tr>
</thead>
<tbody>
<tr>
<td>AU₁</td>
<td><code>FileNotFoundException</code> with invalid input file name for Export Graphic</td>
<td>Expand ‘File’ menu → Click ‘Export Graphic’ submenu → Enter an invalid file name → Click ‘Save’</td>
</tr>
<tr>
<td>AU₂</td>
<td><code>FileNotFoundException</code> with invalid input file name for Export All Graphic</td>
<td>Expand ‘File’ menu → Click ‘Export All Graphics’ submenu → Enter an invalid file name → Click ‘Save’</td>
</tr>
<tr>
<td>AU₃</td>
<td>An inappropriate exception trace printed out when deleting object with a blank document</td>
<td>Expand ‘Edit’ menu → Click ‘Delete from Model’ submenu</td>
</tr>
<tr>
<td>JR₁</td>
<td><code>FileNotFoundException</code> with a non-existing Journal abbreviation file</td>
<td>Expand ‘Option’ menu → Click ‘Manage journal abbreviation’ submenu → Enter an invalid New file name → Click ‘OK’</td>
</tr>
<tr>
<td>JR₂</td>
<td><code>MalformedURLException</code> with an invalid Journal abbreviation download URL</td>
<td>Expand the ‘Option’ menu → Open ‘Journal abbreviation’ window → Click ‘Download’ button → Enter an invalid URL → Click ‘OK’</td>
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<tr>
<td>JR₃</td>
<td><code>NullPointerException</code> with invalid import folder name</td>
<td>Expand ‘Option’ menu → Click ‘Manage custom imports’ submenu → Click ‘Add from folder’ → Enter a non-existing folder path → Click ‘Cancel’</td>
</tr>
<tr>
<td>JR₄</td>
<td><code>ZipException</code> with invalid zip file name</td>
<td>Expand ‘Option’ menu → Click ‘Manage custom imports’ submenu → Click ‘Add from jar’ → Enter a non-existing zip file name → Click ‘Select a Zip-archive’</td>
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</table>

Expand the ‘Option’ menu -> Open ‘Journal abbreviation’ window -> Click ‘Download’ button -> enter an invalid URL -> Click ‘OK’
GUITAR –
Test Case Execution & Evaluation

MalformedURLException with an invalid Journal abbreviation download URL:
“CRASH ME”

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<td>MalformedURLException with an invalid Journal abbreviation download URL</td>
<td>Expand the ‘Option’ menu → Open ‘Journal abbreviation’ windows → Click ‘Download’ button → Enter an invalid URL → Click ‘OK’</td>
</tr>
<tr>
<td>JR3</td>
<td>NullPointerException with invalid import folder name</td>
<td>Expand ‘Option’ menu → Click ‘Manage custom imports’ submenu → Click ‘Add from folder’ → Enter a non-existing folder path → Click ‘Cancel’</td>
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<tr>
<td>JR4</td>
<td>ZipException with invalid zip file name</td>
<td>Expand ‘Option’ menu → Click ‘Manage custom imports’ submenu → Click ‘Add from jar’ → Enter a non-existing zip file name → Click ‘Select a Zip-archive’</td>
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GUITAR –
Test Case Execution & Evaluation

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*The text “CRASH ME” was provided by the testers – but the app should not have been crashed; instead it should have handled the incorrect input properly.*

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- GUI Testing
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- Visual Testing
  - SikuliX
  - Lab 7
- Security Testing
- Usability Testing
- A/B Testing
‘Scriptless’ testing tool Testar

- Scripts are generated automatically (on-the-fly)
- No maintenance of scripts needed
- Main purpose: Robustness testing
  - Robustness is the ability of a computer system to cope with errors during execution and cope with erroneous input

[Link to Testar.org]
Testar tool (1)

- GUI contains graphical objects called widgets
- Widgets form a hierarchy called widget tree
- Widgets have properties (title, etc.)
- Widget tree and properties of each widget form a GUI state
- GUI state changes, if user executes an action (click, write, etc.)
Testar tool (2)

- Example widget of Calculator program
Testar tool (3)

- Widget tree of Calculator program
Testar tool (4) – What it can do ...

Testar always detects (no Oracle needs to be defined)
• ... when SUT crashes
• ... when SUT hangs

protected Verdicts getVerdicts(State state){
    Assert.notNull(state);
    Verdicts verdicts = new Verdicts();
    verdicts.add(oracle_Crash (state));
    verdicts.add(oracle_Responsiveness(state));
    verdicts.add(oracle_SuspiciousTitles(state));
    return verdicts;
}

protected Verdict oracle_Crash (State state){
    if(!state.get(IsRunning, false))
        return new Verdict("System offline! It crashed?");
}

protected Verdict oracle_Responsiveness (State state){
    if(state.get(NotResponding, true))
        return new Verdict("System is unresponsive!");
}

protected Verdicts oracle_SuspiciousTitles(State state){
    Verdicts verdicts = new Verdicts();
    String titleRegEx = settings().get(SuspiciousTitles);

    // search all widgets for suspicious titles
    for(Widget w : state){
        String title = w.get(Title, "");
        if(title.matches(titleRegEx)){
            verdicts.add(new Verdict("......");
        }
    }
    return verdicts;
}
Testar tool (4) – What it can do ...

Testar can also detect:
• ... incorrect behaviour if proper oracles have been defined (checking widget titles)

```java
protected Verdicts getVerdicts(State state){
    Assert.notNull(state);
    verdicts = new Verdicts();
    verdicts.add(oracle_Crash(state));
    verdicts.add(oracle_Responsiveness(state));
    verdicts.add(oracle_SuspiciousTitles(state));
    return verdicts;
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protected Verdict oracle_Crash(State state){
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}
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    if(state.get(NotResponding, true))
        return new Verdict("System is unresponsive!");
}
protected Verdicts oracle_SuspiciousTitles(State state){
    verdicts = new Verdicts();
    String titleRegEx = settings().get(SuspiciousTitles);
    // search all widgets for suspicious titles
    for(Widget w : state){
        String title = w.getTitle("");
        if(title.matches(titleRegEx)){
            verdicts.add(new Verdict("......"));
        }
    }
    return verdicts;
}
```
Testar tool (4) – What it can do ...

protected Verdicts oracle_ImagesTextDescripWAI(State state) {
    Verdicts verdicts = new Verdicts();
    Role role = w.get(Tags.Role);
    if (role.equals("UIAImage") && title.isEmpty())
        verdicts.add(new Verdict(0.1,
                                "No alternate text descr");
    return verdicts;
}

Testar can also detect:
• … incorrect behaviour if proper oracles have been defined
  (checking widget titles)

Example:
Checks a specific requirement, i.e., requesting that all images
must have a textual description (i.e., oracle checks that widget title
text is not empty)
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Sikuli IDE

Capture images of the GUI

Then write tests using those images

... e.g., to test email forwarding with Gmail ...
How Sikuli X mimics the user’s behavior:

• Find all the check boxes for emails
• Shift coordinate
• Click on the subject line
• Wait for everything to load
• Select the options ‘Reply’ and ‘Forward’ in the list of options
…
Sikuli IDE

Many hints will be given in the Lab 7 session

... and can be found in the documentation.
Lab 7 – Visual GUI Testing (Sikuli IDE)

Lab 7 (week 32: Apr 06 & 07) – Visual GUI Testing (9 points)

Lab 8 Instructions & Tools

Submission Deadlines:
- Tuesday Labs: Monday, 12 Apr, 23:59
- Wednesday Labs: Tuesday, 13 Apr, 23:59

- Penalties apply for late delivery: 50% penalty, if submitted up to 24 hours late; 100 penalty, if submitted more than 24 hours late
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Software Product Quality Model
– ISO 25010 Standard
Security Testing – Why?

• Primary purpose of security testing is to identify the vulnerabilities and subsequently repairing them

• Security Testing helps in
  • improving the current system
  • ensuring that the system will work for longer time
  • finding out loopholes that can cause loss of important information
Security Testing – What?

• Security Testing = Type of testing that …
  • intends to uncover vulnerabilities of the system and
  • determine that its data and resources are protected from possible intruders

• Focus Areas:
  • Network security: This involves looking for vulnerabilities in the network infrastructure (resources and policies).
  • System software security: This involves assessing weaknesses in the various software (operating system, database system, and other software) the application depends on.
  • Client-side application security: This deals with ensuring that the client (browser or any such tool) cannot be manipulated.
  • Server-side application security: This involves making sure that the server code and its technologies are robust enough to fend off any intrusion.
Security Testing – Basic Concepts

• Confidentiality
• Integrity
• Authentication
• Authorization
• Accountability
• Non-repudiation
• [Availability]
Security Testing – Basic Concepts

- Confidentiality
- Integrity
- Authentication
- Authorization
- Accountability
- Non-repudiation
- [Availability]

is about …
… ensuring that information is accessible only for those with authorized access (=> privacy)
and
… preventing information theft
Security Testing – Basic Concepts

- Confidentiality
- **Integrity**
- Authentication
- Authorization
- Accountability
- Non-repudiation
- [Availability]

is about …

… allowing the receiver of data to determine that the information which the data is providing is correct
Security Testing – Basic Concepts

- Confidentiality
- Integrity
- **Authentication**
- Authorization
- Accountability
- Non-repudiation
- [Availability]

is about …

… establishing the identity of the user
Security Testing – Basic Concepts

• Confidentiality
• Integrity
• Authentication
• Authorization
• Accountability
• Non-repudiation
• [Availability]

is about …

… determining that a data requester is allowed to receive a service or perform an operation
Security Testing – Basic Concepts

- Confidentiality
- Integrity
- Authentication
- Authorization
- Accountability
- Non-repudiation
- [Availability]

is about …

… taking responsibility (and transparency about the responsibilities taken) for establishing security
Security Testing – Basic Concepts

- Confidentiality
- Integrity
- Authentication
- Authorization
- Accountability
- Non-repudiation
- [Availability]

is about …
… preventing the later denial that an action happened or a communication took place, etc.
Security Testing – Basic Concepts

- Confidentiality
- Integrity
- Authentication
- Authorization
- Accountability
- Non-repudiation
- [Availability] is about …

... assuring that information and communications services will be ready for use when expected/needed
Security Testing – What?

Main security testing practices include:

• Vulnerability Scanning
• Security Scanning
• Penetration Testing
• Ethical Hacking
• Risk Assessment
• Security Auditing
• Posture Assessment
• Password cracking
Security Testing – What?

Main security testing practices include:

• **Vulnerability Scanning** — Involves scanning of the application for all known vulnerabilities
  Typically done with the help of vulnerability scanning software, e.g., Nessus, Nikto, Gendarme, Flawfinder, etc.

• Security Scanning
• Penetration Testing
• Ethical Hacking
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Security Testing – What?

Main security testing practices include:

- Vulnerability Scanning
- **Security Scanning**
- Penetration Testing
- Ethical Hacking
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- Security Auditing
- Posture Assessment
- Password cracking

Involves scanning the usage of a system in operation to monitor whether attacks on the system are being tried or perhaps prepared.
Main security testing practices include:

- Vulnerability Scanning
- Security Scanning
- **Penetration Testing**
- Ethical Hacking
- Risk Assessment
- Security Auditing
- Posture Assessment
- Password cracking

Testers try to (unauthorized) enter into the application with the help of another software system and via (combinations of) loopholes that the application has kept open unknowingly.
Main security testing practices include:

- Vulnerability Scanning
- Security Scanning
- Penetration Testing
- **Ethical Hacking**
- Risk Assessment
- Security Auditing
- Posture Assessment
- Password cracking

Involves the performance of penetration tests over the wide network on the system under test

Conducted by ethical hackers who try to find possible problems in the system
Security Testing – What?

Main security testing practices include:

• Vulnerability Scanning
• Security Scanning
• Penetration Testing
• Ethical Hacking
• **Risk Assessment**
• Security Auditing
• Posture Assessment
• Password cracking

Analyzing and deriving the risk as a function of potential damage (or loss) and the possibility of damage occurrence

Typically carried out in the form of scenario analysis, interviews, and expert discussions
Security Testing – What?

Main security testing practices include:

• Vulnerability Scanning
• Security Scanning
• Penetration Testing
• Ethical Hacking
• Risk Assessment
• **Security Auditing**
• Posture Assessment
• Password cracking

Involves hands-on internal inspection of Operating Systems and Applications, often via line-by-line inspection of the code.

A security audit is a systematic evaluation of the security of a software system used by a company.
Security Testing – What?

Main security testing practices include:

• Vulnerability Scanning
• Security Scanning
• Penetration Testing
• Ethical Hacking
• Risk Assessment
• Security Auditing
• **Posture Assessment**
• Password Cracking

combines Security Scanning, Ethical Hacking and Risk Assessments to show an overall Security Posture (=attitude towards security) of the organization using a software system
Security Testing – What?

Main security testing practices include:

• Vulnerability Scanning
• Security Scanning
• Penetration Testing
• Ethical Hacking
• Risk Assessment
• Security Auditing
• Posture Assessment
• **Password Cracking**

Password cracking programs can be used to identify weak passwords.
Password cracking verifies that users are employing sufficiently strong passwords.
Security Testing – What?

Example of a basic security test:
• Log into the web application.
• Log out of the web application.
• Click the BACK button of the browser (Check if you are asked to log in again or if you are provided the logged-in application.)

• Most types of security testing involve complex steps and out-of-the-box thinking but, sometimes, it is simple tests like the one above that help expose the most severe security risks.

The Open Web Application Security Project (OWASP) is a great resource for software security professionals.

Check out the Testing Guide:  

OWASP Top 10 security threats for 2013 were:
- Injection
- Broken Authentication and Session Management
- Cross-Site Scripting (XSS)
- Insecure Direct Object References
- Security Misconfiguration
- Sensitive Data Exposure
- Missing Function Level Access Control
- Cross-Site Request Forgery (CSRF)
- Using Known Vulnerable Components
- Unvalidated Redirects and Forwards
The Open Web Application Security Project (OWASP) is a great resource for software security professionals. Be sure to check out the Testing Guide: https://www.owasp.org/index.php/Category:OWASP_Testing_Project

**OWASP Top 10 security threats for 2013 were:**
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How to avoid SQL injection vulnerability?

Instead of:

```java
String query = "SELECT * FROM Users WHERE Username= " +
    request.getParameter("username") +
    "AND Password= " +
    request.getParameter("password");

try {
    Statement statement = connection.createStatement();
    ResultSet results = statement.executeQuery(query);
}
```

Which might result in a SQL query string like this:

```
SELECT * FROM Users WHERE Username='1' OR '1' = '1' AND
    Password='1' OR '1' = '1'
```
How to avoid SQL injection vulnerability?

Use java ‘prepared statement’:

```java
String username = request.getParameter("username");
String password = request.getParameter("password");
// perform input validation to detect attacks

String query = "SELECT * FROM Users WHERE Username= ? AND Password= ?";
PreparedStatement pstmt = connection.prepareStatement(query);
pstmt.setString( 1, username);
pstmt.setString( 2, password);

ResultSet results = pstmt.executeQuery();
```

Example with Hibernate Query Language (HQL) can be found here:

https://cheatsheetseries.owasp.org/cheatsheets/SQL_Injection_Prevention_Cheat_Sheet.html
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Software Product Quality Model – ISO 25010 Standard

Usability
## Testing Usability Requirements

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<tr>
<th>Problem counts</th>
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<tr>
<td>R1: At most 1 of 5 novices shall encounter critical problems during tasks Q and R. At most 5 medium problems on list.</td>
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<table>
<thead>
<tr>
<th>Task time</th>
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<tr>
<td>R2: Novice users shall perform tasks Q and R in 15 minutes. Experienced users tasks Q, R, S in 2 minutes.</td>
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<th>Keystroke counts</th>
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<td>R3: Recording breakfast shall be possible as guest. No mouse.</td>
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<td>R4: 80% of users shall find system easy to use and recommend system to others.</td>
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<td>R5: Show 5 users 10 common error messages and ask for the cause. 80% of the users shall identify error messages as large.</td>
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<tr>
<th>Design-level reqs</th>
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<tr>
<td>R6: System shall use screen pictures in app. xx, buttons work as app. yy.</td>
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<td>R7: For all code fields, user shall be able to select value from drop-down list.</td>
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<tr>
<td>R8: System shall follow style guide zz. Menus shall have at most three levels.</td>
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<th>Development process reqs</th>
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<td>R9: Three prototype versions shall be made and usability tested during design.</td>
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Testing Usability Requirements

How to test:
- Define several (typical) usage scenarios involving tasks Q and R
- Select test users and classify as 'novice' and 'experienced'
- Let 5 (or better 10, 15) novices perform the scenarios
- Observe what problems they encounter
- Classify and count observed problems

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<td>R5: Show 5 users 10 common error messages, e.g. <em>Amount too large</em>. Ask for the cause. 80% of the answers shall be correct.</td>
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Rubin’s Types of Usability Tests (Rubin, 1994, p. 31-46)

**Exploratory test** – early product development

**Assessment test** – most typical, either early or midway in the product development

**Validation test** – confirmation of product’s usability

**Comparison test** – compare two or more designs; can be used with other three types of tests
Usability Testing – What? How?

- Test Focus
  - Understandability
    - Easy to understand?
  - Ease of learning
    - Easy to learn?
  - Operability
    - Matches purpose & environment of operation?
    - Ergonomics: color, font, sound, ...
  - Communicativeness
    - In accordance with psychological characteristics of user?

- Test Environments
  - Free form tasks
  - Procedure scripts
  - Paper screens
  - Mock-ups
  - Field trial
Evaluating UI Designs

- Inspection Methods
  - Heuristic Evaluation
    - Cognitive Walkthrough
    - Guidelines Review
- Usability Testing
  - Laboratory Experiment
  - Field Study
Evaluating UI Designs

- Inspection Methods
  - Heuristic Evaluation
    - Cognitive Walkthrough
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- Usability Testing
  - Laboratory Experiment
  - Field Study

Cheap

Expensive
Evaluating UI Designs

- **Inspection Methods**
  - Cognitive Walkthrough
  - Heuristic Evaluation

- **Usability Testing**
  - Field Study
  - Laboratory Experiment
  - Review

**Evaluating UI Designs**

- **Cognitive Walkthrough**
  - Evaluates design on how well it supports user in learning task
  - Usually performed by expert in cognitive psychology
  - Expert `walks through' design to identify potential problems using psychological principles
  - Scenarios may be used to guide analysis
Evaluating UI Designs

Inspection Methods

- Heuristic Evaluation

- Cognitive Walkthrough
  - Usability criteria (heuristics) are identified
  - Design examined by experts to see if these are violated

Usability Testing

- Laboratory Experiment

- Field Study

Guidelines
Heuristic Evaluation by Inspection

List of 10 Heuristics according to (Nielsen, 2005):

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List violations of heuristics:

Rank by severity: 0...4
0: positive (or neutral) aspect of system
...
4: major, catastrophic aspect of system


### Visibility of system status:

At all times, the system should inform the end user what is currently ongoing, e.g., via timely and adequate feedback.

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Match between the system and the real world:

The system should speak the language of the end user (i.e., it should use adequate terminology from the domain of the end user).

The system should follow the conventions of the real world and present information in a logic and well-structured form.


Heuristic Evaluation

List of 10 Heuristics according to (Nielsen, 2005):

| 1 | Visibility of system status |
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| 3 | User control and freedom |
| 4 | Consistency and standards |
| 5 | Error prevention |
| 6 | Recognition rather than recall |
| 7 | Flexibility and efficiency of use |
| 8 | Aesthetic and minimalist design |
| 9 | Help users recognize, diagnose, and recover from errors |
| 10 | Help and documentation |

User control and freedom:
End users often select a certain function by accident; in that case, they should be able to easily find a way out of this unwanted system state, e.g., by simply choosing ‘undo’ or ‘redo’ functionality.

Rank by severity: 0...4
0: positive (or neutral) aspect of system
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4: major, catastrophic aspect of system


Heuristic Evaluation

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Consistency and standards:

End users should not have to ask themselves whether different words (or symbols) and actions mean the same or do the same.

Conventions that are typical for the used platform should be honored.

4: major, catastrophic aspect of system


Heuristic Evaluation

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Error prevention:

Even better than error messages is it to design the UI such that no errors occur, i.e., situations in which the end user might make a mistake should be avoided.

Before a transaction with potentially incorrect end user input is executed, a dialog seeking confirmation is useful.
### Heuristic Evaluation

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**Recognition rather than recall:**

The cognitive load of the end user can be reduced by making objects actions and options visible and recognizable.

End users should not be forced to remember information when moving from one dialog step to the next.

Help text should always be easily visible or, at least, easy to find.
### Flexibility and efficiency of use:

Shortcuts and special keys – often not known by novice users – can be helpful to expert users and make their interaction with the system more efficient.

The system should be usable according to the needs of different user groups (=flexibility).
Heuristic Evaluation

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Aesthetic and minimalist design:

(Standard) dialogs shouldn’t contain any irrelevant or rarely needed information. Every unnecessary information competes for the attention of the end user with the relevant information and thus diminishes its visibility.

Aesthetics: color, alignment, contrast, proximity

Heuristic Evaluation

List of 10 Heuristics according to (Nielsen, 2005):

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Help users recognize, diagnose, and recover from errors:

Error messages should use simple language, not contain cryptic codes, clearly identify the problem, and make a constructive solution to solve the problem.

0: positive (or neutral) aspect of system
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### Heuristic Evaluation

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**Help and documentation:**

Ideally, a system should be usable without documentation (→ self-explanatory), sometimes it is useful to offer help.

Help texts and documentation should be easy to find and search.

Help texts and documentation should focus on the end users’ (typical) needs and offer concrete steps on how to use the system for a specific task.
Evaluating UI Designs

- Inspection Methods
  - Heuristic Evaluation
    - Cognitive Walkthrough
  - Guidelines Review
- Usability Testing
  - Laboratory Experiment
  - Field Study
Evaluating UI Designs

Written guidelines recommended for larger projects:

- Screen layout
- Appearance of objects
- Terminology
- Wording of prompts and error messages
- Menu’s
- Direct manipulation actions and feedback
- On-line help and other documentation
Guidelines for Screen Layout & Appearance

P.A.R.C.

- Proximity
- Alignment
- Repetition
- Contrast
Guidelines for Screen Layout & Appearance

P.A.R.C.

1. Proximity
   Objects that are close to another (related) appear to form groups.

2. Alignment

3. Repetition

4. Contrast
Guidelines for Screen Layout & Appearance

P.A.R.C.
- Proximity
- Alignment
- Repetition
- Contrast

Alignment of objects generates clarity / avoids confusion.

- O-O-O-O-O-O-O-O-O-O-O-O
  in ALIGNMENT

- O-O-O-O-O-O-O-O-O-O-O-O
  out of ALIGNMENT
Guidelines for Screen Layout & Appearance

P.A.R.C.

- Proximity
- Alignment
- Repetition
- Contrast

Visual aspects such as color, shape and size link (similar) items together.
Guidelines for Screen Layout & Appearance

P.A.R.C.

- Proximity
- Alignment
- Repetition
- Contrast

Contrast makes differences easier recognizable.
Guidelines for Screen Layout & Appearance

Contrast makes differences easier recognizable. Use: size, color, value, shape, position, direction, …
Evaluating UI Designs

Inspection Methods
- Heuristic Evaluation
- Cognitive Walkthrough

Usability Testing
- Laboratory Experiment
- Guidelines Review
- Field Study
Evaluating UI Designs

Usability testing in a controlled environment
- There is a test set of users
- They perform pre-specified tasks
- Data is collected (quantitative and qualitative)
- Take mean and/or median value of measured attributes
- Compare to goal or another system
Evaluating UI Designs

1. Direct observation in actual use
   - discover new uses
   - take notes, don’t help, chat later

2. Logging actual use
   - objective, not intrusive
   - great for identifying errors
   - which features are/are not used
   - privacy concerns

Cognitive Walkthrough

Guidelines Review

Usability Testing

Field Study
Evaluating UI Designs

3. Questionnaires and interviews with real users
   - ask users to recall critical incidents
   - questionnaires must be short and easy to return

4. Focus groups
   - 6-9 users
   - skilled moderator with pre-planned script
   - computer conferencing??

5. On-line direct feedback mechanisms
   - initiated by users
   - may signal change in user needs
   - trust but verify

6. Bulletin boards and user groups
UI Design & Usability

Recommendation for those who want to know more about UI Design (and Usability):

• Course: LTAT.05.007 - Human Computer Interaction
• Teacher: Alexander Nolte
Structure of Lecture 8

- GUI Testing
  - GUITAR
  - TESTAR
- Visual Testing
  - Sikuli IDE
  - Lab 7
- Security Testing
- Usability Testing
- A/B Testing
A/B Testing

Two GUI Versions A & B
A/B Testing (cont’d)

Visual Website Optimizer divides traffic between the two versions

Tool support

Randomly selected

Two GUI Versions A & B

FreshCatch.com
A/B Testing (cont’d)

Tools:
https://blog.crazyegg.com/2014/06/25/best-testing-software/

Two GUI Versions A & B
A/B Testing – Real-World Example

Former US president Obama’s 2008 Election campaign

A/B Testing – Real-World Example

Button variations:
A/B Testing – Real-World Example

Media variations:

- Family Image
- Change Image
- Barack’s Video
- ...

(6 alternatives in total)
**A/B Testing – Real-World Example**

In total

4 x 6 = 24 combinations

(including the original button and medium)

Sign-up rates for each section (button, medium)
A/B Testing – Real-World Example

In total
4 x 6 = 24 combinations
(including the original button and medium)

Combination 11:
“Learn More” & “Family Image”

Sign-up rates for each <button, medium>-combination
A/B Testing – Real-World Example

Former US president Obama’s 2008 Election campaign


Combination 11: “Learn More” & “Family Image”
A/B Testing – Multivariate Testing

• Only 2 items in previous example
A/B Testing (cont’d)

What to vary ...

- Call-To-Actions – Placement, wording, size
- Copywriting – Value propositions, product descriptions
- Forms – Their length, field types, text on the forms.
- Layout – Homepage, content pages, landing pages
- Product pricing – Try testing for revenue by testing your prices
- Images/Videos – Their placement, content and size
- Amount of content on the page (short vs. long)

Link:

http://conversionxl.com/how-to-build-a-strong-ab-testing-plan-that-gets-results/
A/B Testing -- Tools

A/B Split Test Significance Calculator by VWO

• A widely used tool for calculating the significance of your A/B testing results.

A/B Split and Multivariate Test Duration Calculator by VWO

• The calculator allows you to calculate maximum duration for which your test should run.

Crazyegg, Inspectlet, Clicktale and Mouseflow

• Heatmap software for tracking your visitor’s behavior on your site. You can get good data for hypotheses generation.
Next Week

- Quiz 8 → Moodle
- Lab 7:
  - Visual Testing
- Lecture 9:
  Security Testing of Mobile Applications (Kristiina Rahkema)