Testing Method for Intelligent Robot Software Components

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1. Why is Testing needed?

2. What is URC?

3. Software Functions of URC Robots

4. Applying ISO/IEC 9126 (Software Product Quality) Standards to the Robot Testing

5. Test Case Design for URC Software

6. Conclusion

7. Appendix:
   - ISO/IEC 9126: Definition of Quality Characteristics
   - URC Robot Quality Certification Process
1. Why is Testing needed?

Testing means:
- inspecting the products in order to determine whether they meet the requirements.
- detecting the defects of the system.

Purpose of Testing
- Assurance of products without defects
- In reality, there is no perfect testing system that can detect all defects. It reduces defect risks as much as possible.
- Testing promotes quality of products.

Software has a key role in an intelligent robot system.
- Quality Assurance for Software is necessary.
- A well-structured and reliable test process is needed.
- ISO/IEC 9126 (Software Product Quality) is adopted for this purpose.
2. What is URC (Ubiquitous Robot Companion)?

A Robot which provides various required services “whenever” and “wherever”

→ Robot Tech. + Information Telecommunication Tech. using IT infra systems
URC Infra System - URC Pilot Business

- High Usability Clustering Server Tech.
  (Simultaneously 100 users connected)
- Service Component QoS tech
  (Audio/Video Realtime Processing Assurance)
- User Security Tech.

- Tele Robot Control & Monitoring tech.
- Software Robot Engine for Context-awareness
- Mobile Device & Web based Software Tech.

URC Network
- Realtime Service & Connectivity Assurance Wire/Wireless network tech
- Control & Security Protocol tech between Robot & Sever

IPv4/v6 Internet
CDMA

Teleoperation Terminal
Software Robot

Home Server/Home gateway
Wireless Gateway
### 3.1 HRI (Human-Robot Interaction) Software Components

<table>
<thead>
<tr>
<th>HRI component technology</th>
<th>User Recognition</th>
<th>Gesture Recognition</th>
<th>Expression Recognition</th>
<th>Voice Recognition</th>
<th>Voice Decomposition</th>
<th>Voice Pursuit</th>
<th>Speaker Recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infra-Image HRI technology</td>
<td>User's cognition module by an quasi-organism information, facial expression at a long distance in the situation of robot's upward sight</td>
<td>User's pursuit and gesture cognition module development Caller Identification module</td>
<td>Facial component detection and special feature extraction module</td>
<td>Cognitive module of user's voice information transmitted from robot</td>
<td>Conversion module changing arbitrary sentence with composition voice</td>
<td>Exclusion module removing noises in the robot and outside noises for tracking the original sound</td>
<td>Speaker cognition module by the context speaker independent method</td>
</tr>
</tbody>
</table>
User Recognition
## 3.2 URC Robot Smart Action Technology

Consists of intellectual covering technology and intellectual manipulating technology

<table>
<thead>
<tr>
<th>The Intellectual Covering Technology</th>
<th>The correctly searching technology of robot's position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map-Forming Technology</td>
<td>Map-forming technology presented by digital data that grasps the robot's covering environment</td>
</tr>
<tr>
<td>Route-Framing Technology</td>
<td>Route-controlling technology that make the robot plan its course, make it move as the original course</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The Intellectual Manipulating Technology</th>
<th>The cognitive technology that makes the robot recognize the manipulating objects and circumference-environment with using camera, distance sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manipulation-Control Technology</td>
<td>The technology that manipulates the special object with controlling</td>
</tr>
<tr>
<td>Technology</td>
<td>robot's arms articulation</td>
</tr>
</tbody>
</table>
Autonomous Navigation Technology

- Natural mark based Intelligent Navigation Tech.
- Path Navigation Tech.
- Obstacle Avoid Tech.
- Fusion of Imaging info & Ultra sound info (24 hours working)
ISO/IEC 9126 (software Product Quality) can be used to measure quality of URC robot S/W

ISO/IEC 9126 consist of 6 quality characteristics, 27 sub characteristics and 88 metrics

We are now Studying test guideline for URC Robot Component using ISO/IEC 9126
4.1 ISO/IEC 9126 (Software Product Quality) Model

- Extension of ISO 9126 standard for Robotic Software Quality Evaluation Items

Quality Characteristics

- Functionality
- Reliability
- Usability
- Efficiency
- Maintainability
- Portability

Subcharacteristics

- Suitability
- Accuracy
- Interoperability
- Security
- Compliance

- Maturity
- Fault tolerance
- Recoverability
- Compliance

- Understandability
- Learnability
- Operability
- Attractiveness

- Time behavior
- Resource utilization
- Compliance

- Analyzability
- Changeability
- Stability
- Testability
- Comp

- Adaptability
- Installability
- Co-existence
- Replaceability
- Com
<table>
<thead>
<tr>
<th>Number</th>
<th>Metrics</th>
<th>Quality SubCharacteristics</th>
<th>Quality Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Function Implementation Completeness (FIC)</td>
<td>Suitability</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Accuracy of Defined Functionality (ADF)</td>
<td>Accuracy</td>
<td>Functionality</td>
</tr>
<tr>
<td>14</td>
<td>Access Monitoring Capability (AMC)</td>
<td>Security</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Function Conformity Rate (FCR)</td>
<td>Security</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Interface Conformity Rate (ICR)</td>
<td>conformity</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Fault Occurrence Rate (FOR)</td>
<td>Maturity</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Down Avoidance Rate (DAR)</td>
<td>Fault tolerance</td>
<td>Reliability</td>
</tr>
<tr>
<td>24</td>
<td>Failure Avoidance Rate (FAR)</td>
<td>Fault tolerance</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Data Recovery Rate (DRR)</td>
<td>Recoverability</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Mean Response Time (MST)</td>
<td>Time behavior</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Mean Transaction Time (MTT)</td>
<td>Time behavior</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Data Transfer Rate (DTR)</td>
<td>Time behavior</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Error Recovery Allowance (ERA)</td>
<td>Operability</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>Error Prevent Allowance (EPA)</td>
<td>Operability</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Message Readability Allowance (MRA)</td>
<td>Operability</td>
<td></td>
</tr>
</tbody>
</table>
4.2 Robotic Software Testing Model

- **Testing (Certifying) Reference**
  - Selecting items for testing (Certifying)
  - Designing reference value for evaluation & satisfaction

- **Test Committee**

- **Testing & Evaluation Check list**
  - Selecting items for testing (Certifying)
  - Designing reference value for evaluation & satisfaction

- **Items for testing (ISO9126)**
  - Reference for evaluation & Satisfaction of requirements

- **Evaluation Module**
  - Testing Methods of sub-items
  - Testing process
  - Testing form

- **Testing & Evaluation**

- **Judging for satisfaction**
URC Software Requirements are related into ISO 9126 metric

### 1. Image recognition

<table>
<thead>
<tr>
<th>Requirement id.</th>
<th>Requirement description</th>
<th>ISO 9126 metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFR.HI.01</td>
<td>Provide a learning tool using “Template Update Algorithm”.</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HI.02</td>
<td>Provide a “back lighted detect function size of face, as well as GPS verification”.</td>
<td>FIA</td>
</tr>
<tr>
<td>SFR.HI.03</td>
<td>Provide a “street measuring information” using supersonic sensor.</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HI.04</td>
<td>Provide a “register and non-register distinction function” through boundary value.</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HI.05</td>
<td>Provide a “detect function” in 15 degree (up&amp;down, left&amp;right, front&amp;back).</td>
<td>FIC</td>
</tr>
<tr>
<td>SNR.HI.PE.01</td>
<td>The target users’ recognition rate must reach more than 95%, in three meters of light</td>
<td>FIC</td>
</tr>
<tr>
<td>SNR.HI.PE.02</td>
<td>Processing speed should be reached P4,3G CPU, 1G RAM at 5 frm/sec</td>
<td>TB</td>
</tr>
</tbody>
</table>
### Requirement Specification vs. ISO 9126 metric (2)

#### 2. Voice Recognition

<table>
<thead>
<tr>
<th>Requirement id.</th>
<th>Requirement description</th>
<th>ISO 9126 metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFR.HS.01</td>
<td>Provide an easy way on-line registration using GUI (speaker registration)</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HS.02</td>
<td>Provide “independent sentence speaker recognition”</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HS.03</td>
<td>Provide a “detect function” and “speaker recognition” between family members.</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HS.04</td>
<td>Provide “strength of signal regularity function” and “choice of microphone” for the long distance transaction purpose.</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HS.05</td>
<td>Provide “speaker recognition function” using three or more microphone.</td>
<td>FIA</td>
</tr>
<tr>
<td>SFR.HS.06</td>
<td>Provide a “noise filter” and “noise detect function”.</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HS.07</td>
<td>Provide a guidance system after detecting noise</td>
<td>UGA</td>
</tr>
<tr>
<td>SFR.HS.08</td>
<td>Provide a sex and age identification system.</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HS.09</td>
<td>Provide a adoptable speaker recognition</td>
<td>FIC</td>
</tr>
<tr>
<td>SNR.HS.PE.01</td>
<td>“Speaker recognition” and “verification rate” must reach more than 95% when noise level reaches 5~15dB</td>
<td>FIA</td>
</tr>
<tr>
<td>SNR.HS.PE.02</td>
<td>While someone suing on-line registration, this system must be able to register using two or less sentences.</td>
<td>FIA</td>
</tr>
<tr>
<td>SNR.HS.PE.03</td>
<td>This system must be able to recognize categories in all four directions within three meters.</td>
<td>FIC</td>
</tr>
</tbody>
</table>
## Requirement Specification vs. ISO 9126 metric (3)

### 3. Image interaction

<table>
<thead>
<tr>
<th>Requirement id.</th>
<th>Requirement description</th>
<th>ISO 9126 metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFR.HR.01</td>
<td>Provide a “face detect function” (with in 3m).</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HR.01</td>
<td>Provide a (head detect function), based on Omega.</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HR.01</td>
<td>Provide a “follower identification function” using colored clothes.</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HR.01</td>
<td>Provide “follower identification function” using GPS location system between previous screen and current screen.</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HR.01</td>
<td>If the Robert looses its follower, then provide a voice message and alarm using TTS.</td>
<td>FIC</td>
</tr>
<tr>
<td>SFR.HR.01</td>
<td>If the Robert looses its follower, this system will save pursuit info automatically. After a while, if this system find exact same follower, then he/she will follow the Robert continuously.</td>
<td>FIC</td>
</tr>
<tr>
<td>SNR.HS.PE.01</td>
<td>Frontal verification rate must reach more than 95% in one to three meters.</td>
<td>FIA</td>
</tr>
<tr>
<td>SNR.HS.PE.02</td>
<td>Personal identification efficiency must reach more than 95% when it does not have occlusion.</td>
<td>FIA</td>
</tr>
<tr>
<td>SNR.HS.PE.03</td>
<td>Flank and rear verification rate must reach more than 90%</td>
<td>FIA</td>
</tr>
</tbody>
</table>
Preconditions for test case design

- what is the method that has the highest probability of detecting the errors

- The method should cover all requirement specifications about URC software

- A number of test cases should be reduced effectively.
5.1 Steps for testing method based on Scenario

1. Identify the workable requirements in the specification

2. Assign an unique number to each user requirements.

3. Design Test scenario by combining requirement. Each requirement should be included by least one scenario.

4. Until all requirements have been covered by scenario, make new scenario.

5. Design Test cases which can satisfy each scenario.
5.2 Development Process for Testing Method Specifications

- ISO 9126
  - Component Requirement
    - Testing Requirement /Design
      - Testing Items
      - Testing Specification Development
        - Testing Reference
    - Testing/Assessing
      - Test Case
        - Testing/Assessing Report
      - Testing/Standardization
        - Experts Opinions
6. Conclusion

- We propose the testing method for URC component quality
- We are defining the guideline for URC Robot Requirements
- Test case design using scenario will be an effective method
- The work is based on ISO/IEC 9126
7.1 Appendix: Definition of Functionality Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality</td>
<td>The capability of the software product to provide functions that meet needs when the software is used under the specified condition</td>
</tr>
<tr>
<td>Suitability</td>
<td>The capability of the software product to provide an appropriate set of functions for specified tasks and user objectives</td>
</tr>
<tr>
<td>Accuracy</td>
<td>The capability of the software product to provide the right or agreed results or effects with the needed degree of precision.</td>
</tr>
<tr>
<td>Interoperability</td>
<td>The capability of the software product to interact with one or more specified systems.</td>
</tr>
<tr>
<td>Security</td>
<td>The capability of the software product to protect information &amp; data so that only authorized persons or systems are accessed to them.</td>
</tr>
<tr>
<td>Functional compliance</td>
<td>The capability of the software product to adhere to standards, conventions or regulations in laws and similar prescriptions relating to functionality.</td>
</tr>
</tbody>
</table>
7.1 Appendix: Definition of Reliability Characteristics

- **Reliability**: The capability of the software product to maintain a specified level of performance when used under specified conditions.

- **Maturity**: The capability of the software product to avoid failure as a result of faults in the software.

- **Fault tolerance**: The capability of the software product to maintain a specified level of performance in case of software failure or infringement of its specified interface.

- **Recoverability**: The capability of the software product to re-establish a specified level of performance and recover the data directly affected in the case of a failure.

- **Reliability compliance**: The capability of the software product to adhere to standards, conventions or regulations relating to reliability.
7.1 Appendix: Definition of Reliability Characteristics

Usability

The capability of the software product to be understood, learned, used and attractive to the user under specified conditions.

Understandability

The capability of the software product to enable the user to understand whether the software is suitable, and how it can be used for particular tasks and conditions of use.

Learnability

The capability of the software product to enable the user to learn its application.

Operability

The capability of the software product to enable the user to operate and control it.

Attractiveness

The capability of the software product to enable the user to be attractive to users.

Usability compliance

The capability of the software product to adhere to standards, conventions, style guides or regulations relating to usability.
7.1 Appendix: Definition of Efficiency Characteristics

**Efficiency**

The capability of the software product to provide appropriate performance, relative to the amount of resources used, under stated conditions.

**Time behavior**

The capability of the software product to provide appropriate response and processing times and throughput rates when performing its functions under stated conditions.

**Resource behavior**

The capability of the software product to provide appropriate amounts and types of resources when the software performs its functions under stated conditions.

**Efficiency compliance**

The capability of the software product to adhere to standards or conventions relating to efficiency.
7.1 Appendix: Definition of Maintenability Characteristics

- **Maintainability**: The capability of the software product to be modified. Modifications may include corrections, improvements or adaptation of the software to changes in environment, and in requirement, functional specifications.

- **Analyzeability**: The capability of the software product to be diagnosed for deficiencies or causes of failures in the software, or for the parts to be modified to be identified.

- **Changeability**: The capability of the software product to enable a specified modification to be implemented.

- **Stability**: The capability of the software product to avoid unexpected effects from modifications of the software.

- **Testability**: The capability of the software product to enable modified software to be validated.

- **Maintainability compliance**: The capability of the software product to adhere to standards or conventions relating to maintainability.
7.1 Appendix: Definition of Portability Characteristics

Portability: The capability of the software product to be transferred from one environment to another.

Adaptability: The capability of the software product to be adopted for different specified environments without applying actions or means other than those provided for the purpose for the software considered.

Installability: The capability of the software product to be installed in a specified environment.

Co-existence: The capability of the software product to co-exist with other independent software in a common environment sharing common resources.

Replaceability: The capability of the software product to be used in place of another specified software product for the same purpose in the same environment.

Portability compliance: The capability of the software product to adhere to standards or conventions relating to portability.
7.2 Appendix: URC Robot Quality Certification Process

- **Robot Purchaser** (Businessman, Consumer)
- **URC Robot Certification committee**
- **Robot Manufacturer & Developer**
- **Advertising to People**

- **Testing Resultant data**
- **Certification request & Application**

- **Use of Quality Certification**
- **Advertising to People**

- **Telecommunication / Service Test**
- **Safety / Reliability Test**
- **Software Test**

- **RF/Electric Characteristics Test**
V. Appendix: URC Robot Certification Test Scope

- **Safety & Reliability Test**
  - Electromagnetic Satisfaction test
- **Communication/Service Test**
- **Electric product Safety test**
- **Form Registration Test**
  - Wireless Lan Interoperability Test