Integration Platform for Metric-Based Analysis of Web User Interfaces

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Abstract. We present a software tool for collecting web UI metrics from different providers and integrating them in a single database for further analysis. The platform's architecture supports both code- and image-based UI assessment, thus allowing to combine advantages of the two approaches. The data structures are based on a web UI measurement domain ontology (OWL) that organizes the currently disperse set of metrics and services. Our platform can be of use to interface designers, researchers, and UI analysis tools developers.

Keywords: User interaction quality · Design mining · HCI vision · User behavior modeling

1 Introduction

Automated assessment of web user interfaces (WUI) quality can be grouped into three major approaches: based on actual interactions, UI metrics, and models [1]. The more advanced hybrid approach implies obtaining the considered UI's quantitative characteristics (metrics) and then using them as input for user behavior models [2]. The output is predicted values for attributes that characterize user interaction quality, which can be used e.g. in automated UI design based on optimization.

The more conventional method for obtaining the metrics is "static" analysis of UI code or model representation. It boasts high performance and accuracy and is particularly suitable for web UIs whose HTML/CSS code is easily available. Code-based analysis is widely used to check compliance with accessibility guidelines and other standards and recommendations. However, the increasing popularity of Web Components leads to an abundance of code with many custom elements that cannot be easily recognized in the DOM. Also, "static" code analysis lacks in considering UI's context of use, so most usability-related quality attributes cannot be assessed with it.

On the other hand, the increasingly popular UI visual analysis [3], which is based on image recognition techniques, assesses the WUI as the target user witnesses it. This "dynamic" method deals with UI's visual representation (e.g. screenshot of a webpage rendered in a browser) and is naturally good at considering layouts, spatial properties of

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web UI elements, graphical content, etc. The main challenge of image-based analysis, besides computational expensiveness, is the accuracy of the recognition. Visual variability in WUI elements nowadays is extremely high, which rules out simple pattern matching. The Machine Learning approach has been shown to be somehow effective [4, 5], but for supervised learning of the classifiers, an annotated training data of appropriate size is needed.

Another challenge in the rapidly developing domain of UI analysis is the abundance and diversity of metrics proposed by various researchers. The names for the metrics are still evolving, different algorithms (not always fully disclosed) can be used to calculate metrics of the same name, one metric can characterize different quality attributes in different models. Thus, we feel there is a need for a conceptual organization of UI metrics and a meta-tool for integrating diverse metrics from different sources and services. So, in our work, we present an OWL-based ontology and a *WUI measurement integration platform* capable of collecting different sets of WUI metrics for further analysis and usage in user behavior models.

2 WUI Measurement Integration Platform

In order to structure the WUI metrics domain, we built an ontology in OWL (Protégé 5.5.0-beta-4 editor was used). Since no existing ontologies in the field came to our attention, we mostly extracted concepts from published research works and available software. For instance, W3C cataloged more than 100 tools/services for assessing web accessibility[1] and proposed a set of attributes to organize them, including:

- Guidelines (WCAG of different versions, German BITV, French RGGA, Japanese JIS, Korean MAAG, US Section 508, etc.);
- Type of tool (API, Browser plugin, Command line, Desktop, Mobile, Online, etc.);
- Technology (WAI-ARIA, CSS, (X)HTML, ODF, PDF, SVG, SMIL, etc.);
- Output/assistance type (report, evaluation guidance, webpage modification, etc.);
- License type (Commercial, Free, Open Source, Trial or Demo).

The top-level concepts in the ontology include Interface, Attribute, Metric, and Service. The current version has more than 100 classes and about 200 individuals. An extract of the ontology structure visualized with OntoGraph is presented in Fig. 1.

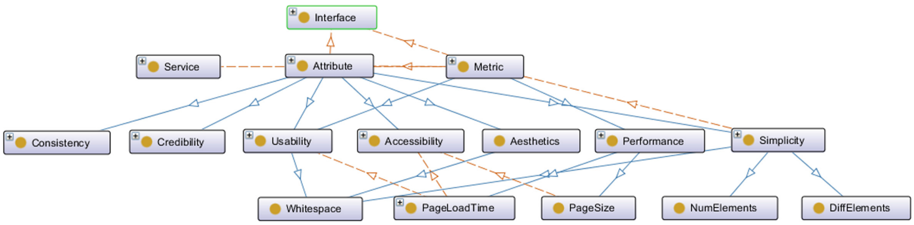

Fig. 1. Selected classes from the WUI measurement ontology.

[1] https://www.w3.org/WAI/ER/tools/.

The ontology served as the basis for the meta-tool that we developed for assessing WUIs using metrics from different providers (cf. Fig. 2). A WUI screenshot or website URI is sent to a remote service using its supported protocol, the metrics and other output are received and saved in the platform's database. The architecture also allows the use of remote services that use code analysis to supply WUI metrics. The platform can be accessed at our "knowledge portal" (http://va.wuikb.online, database dumps with the metrics can be provided upon request).

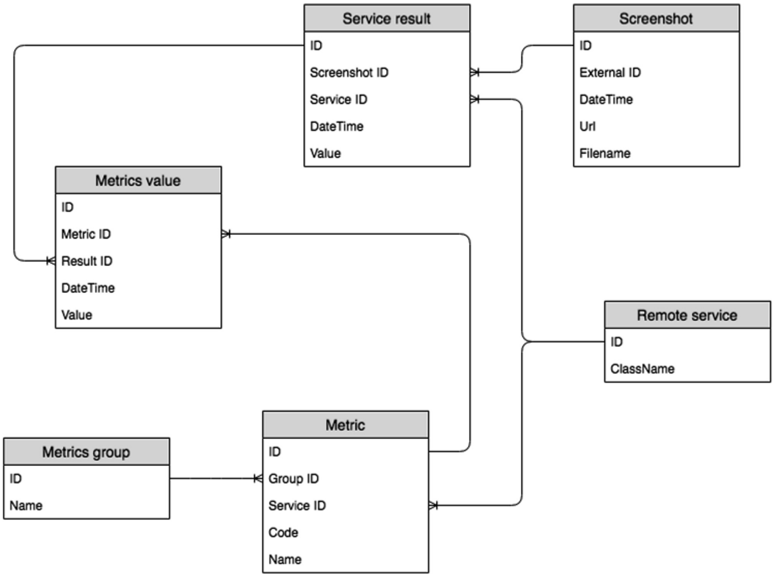

Fig. 2. An extract from WUI measurement platform database structure.

The scheme for the platform is shown in Fig. 3. The remote services currently used are:

1. WUI visual analyzer that we previously developed [4], hosted by TU Chemnitz[2];
2. AIM Interface Metrics [5] launched in 2018 by the team from Aalto University[3].

[2] http://webmining.wuikb.online/ratio/screenshot.php.

[3] http://userinterfaces.aalto.fi/.

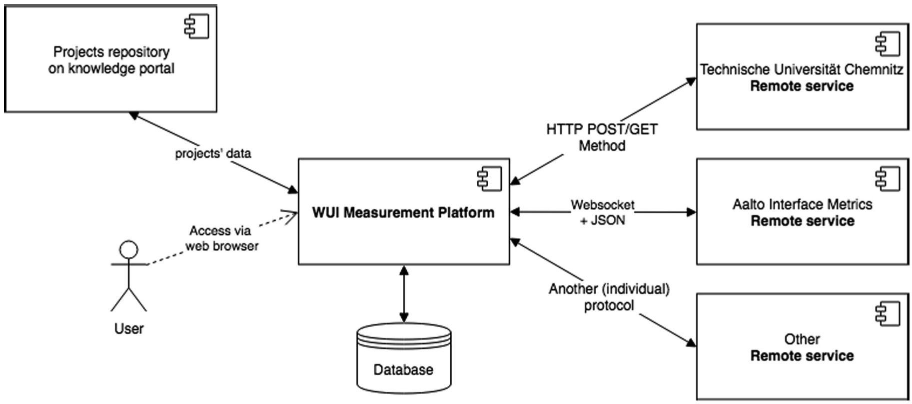

Fig. 3. The scheme for the WUI measurement platform

3 Conclusions

The WUI measurement integration platform that we developed and launched has the potential to combine "static" and "dynamic" analysis of web UIs. We see the following practical advantages in its usage:

- for **interface designers:** obtaining an extended number of metrics for more complete WUI analysis or selecting only project-relevant metrics from different services;
- for **researchers:** performing cross-comparison of different metrics and algorithms and studying their predictive powers w.r.t. user interaction quality assessment;
- for **visual analysis tools developers:** loosening requirements towards amounts of annotated data for training UI element classifiers in supervised learning mode (as element's type can often be easily extracted from the code).

Further prospects include implementation of "batch mode" so that the platform could collect metrics for a specified list of web pages under analysis. Since our tool is open to everyone's use, we welcome collaborators and hope to gradually increase the number of involved services. A more detailed description of the platform, together with an example of its application for researching WUI visual complexity can be found in [6].

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