Digital Preservation of Cultural Heritage: An Ontology-Based Approach

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Abstract

The project aims to design and build a digital portal which will document, organise, and preserve aspects of Balinese cultural heritage and related knowledge for the benefit of the wider community and the younger generations in particular. We present the details of our research dealing with one aspect of Balinese culture, the Balinese traditional communication system (*kulkul*), undertaken in the Indonesian island of Bali. This knowledge is held largely in tacit form in the Balinese community and tends to be poorly documented and fragmented. A basic ontology of key *kulkul*-related concepts and terms and their interrelationships was developed to support the semantic searching and browsing of the online portal and related resources. Much of the content for the portal was acquired through community-based crowdsourcing. We also discuss the procedures employed evaluate the digital portal prototype.

Keywords Balinese *kulkul*, digital heritage, digital portal, ontology, living cultural repository.

1 Introduction

Many countries around the world face the problem of cultural heritage extinction or depletion; a large proportion of the objects and cultural practices are poorly documented. The relevant cultural knowledge tends to be largely tacit and fragmented (Sanabila and Manurung, 2014, Rosner et al., 2014). UNESCO, the international scientific community, and local researchers have repeatedly called for action to protect cultural heritage. Furthermore, in some areas of conflict, museums and cultural heritage sites have been specifically targeted due to their high symbolic value and the attention they attract from tourists and the international media. Also, much valuable cultural knowledge has been lost as a result of the loss of experts and the collapse of administrative structures. It is widely recognised that if concerted action is not taken to document, preserve, and protect the ancient cultural practices and knowledge and ethnicities, languages, and traditions which are part of humanity's intangible heritage, these are at risk of being lost forever.

The world we live is not a static, and cultural knowledge and practices change and evolve over time. Using a traditional method to document and preserve the dynamic cultural knowledge will raise a problem of how the knowledge should be aggregated, stored, retrieved, shared, and updated across multiple people and communities. Cultural heritage knowledge is often an enormous mesh of interrelated facts and concepts, and deploying a multimedia (e.g., text, image, audio, and video) documentation and digital portal building approach can help to capture, represent and share this knowledge. There is also a need to represent the semantic inter-relationships among the key concepts and elements to facilitate the retrieval and application of the relevant knowledge in a context-sensitive manner.

Over the past few decades, digitisation of cultural heritage and natural history has attracted significant attention from researchers, practitioners, and memory institutions (galleries, libraries, archives, museums, and natural history institutions). Digital preservation of cultural heritage is a complex and interdisciplinary endeavour involving diverse disciplines such as computer science, history, library science, literature, information science and art. The goals of digital preservation are to gather, refine, maintain, and share cultural resources that can be used and further developed and enriched by scholars, members of the community, and younger generations. Moreover, digitisation is used to create new means of accessing cultural information, and to enable current users and future generations to learn, understand, and enhance the digital resources through the Internet. A problem encountered in cultural digitisation projects is the preservation of information beyond the actual physical object, such as contextual and cultural practice-related information. UNESCO has identified such practices as very fragile by their very nature and easily forgotten, making the digitisation of this cultural information, vital for preservation (UNESCO, 2011).

Figure 1. Balinese kulkul installed in the Bale kulkul

The focus of this project is on the Balinese *kulkul* and related practices. The Balinese *kulkul* is an artefact which is part of the Balinese traditional communication system and varies from one Balinese village to another. Balinese *kulkul*s are mainly made of wood or bamboo and are installed in the *bale kulkul*, typically around the temple area, custom villages (*desa adat* or *desa pakraman*), and *banjar adat* in every village (see figure 1 for example). *Desa adat* or *desa pakraman* is a custom village on the island of Bali that consists of a group of Balinese people with shared traditions and cultural practices. *Banjar*

adat is a Balinese organisational unit and social groups that follow the Balinese traditional rules and customs, and it is part of *desa adat* or *desa pakraman*. The objects, cultural practices, and messages surrounding the different *kulkul* sounds represent a distinct dimension of Balinese cultural heritage.

In this paper, we discuss the design and development of the basic *kulkul* ontology along with the digital portal prototype and the adoption of the community-based crowdsourcing approach to evolve the *kulkul* ontology and to evaluate the artefact.

The significance of this project is to enhance the understanding of *kulkul* and related practices for the benefit of the Balinese community and others. As mentioned in the foregoing, much of this knowledge is deeply tacit and collectively held within the Balinese community. The primary goal of this research is to externalise the complex body of cultural knowledge and makes it available through the design, construction, and evaluation of an online digital portal.

2 Overview of Design Science Research Methodology

The design science research methodology (DSRM) (Peffers et al., 2007) offers a useful approach to carry out research that has the goal of creating and evaluating design artefacts to address complex problems. As depicted in Figure 2, DSRM comprises several stages: (1) problem identification and motivation; (2) objectives for solutions; (3) design and development; (4) demonstration and evaluation; and (5) communication.

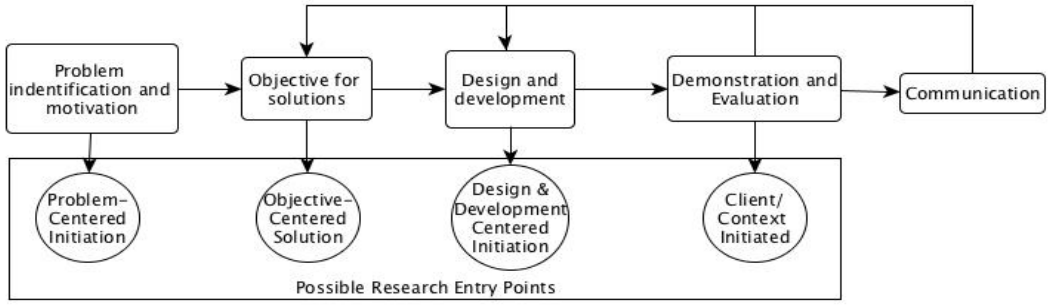

Figure 2. Design Science Research Methodology (DSRM)

First, problem identification and motivation is used to understand and specify the research question that typically based on observations. Second, the objective of the proposed solutions is outlined of how the possible solutions will be able to solve the problem that was described in the previous stage. Third, the design and development phase involves explaining in detail of how the IT artefact is modelled, and what kind of system development methodology is used when developing the artefact. Fourth, demonstration and evaluation are crucial components of the design science research process. The artefact should be demonstrated to the relevant users through experimentation, simulation, or proof-of-concept level prototype to receive user feedback. Evaluation of the artefact including an assessment of the functionality, accuracy, performance, reliability, usability, completeness, and any other component that are relevant to the specified problem should be conducted. Lastly, communication is an activity in which research and other papers relating to the study should be published in academic journals, academic conference proceeding, and other professional outlets

3 Methodology

Our research employs the design science research methodology which starts with a problem-centred approach, in which the first step is the identification of the problem and the motivation for the research. Each of the stages in the methodology as applied to this research is described below.

3.1. Problem-Centred Approach

Our search revealed that a comprehensive tool, framework, and platform that can be used to digitise and share the diverse and fragmented cultural heritage and related-practices resources were not available. Furthermore, the need of an online tool that enables a number of people and communities to contribute, grow, and share their knowledge, and supports the semantic interrelationships among the cultural resources has provided the impetus for the development of the *kulkul* ontology and the digital portal.

3.2. Problem Identification and Motivation

Bali is renowned worldwide as a tourist destination because of its highly-developed culture, including art, traditional dance, painting, music, language, and so forth. It is widely recognised that the Balinese cultural knowledge is complex. Even for cultural and community experts, it is far from straightforward to model this domain of knowledge. Much of this knowledge is held largely in tacit form and rooted in the Balinese community. The absence of a clear documentation of Balinese culture (Walker and Helmi, 1995, Covarrubias, 2008), specifically on Balinese *kulkul*, makes this study particularly challenging and significant. The fact that the *kulkul* artefact and practices are diverse and not standardised makes it particularly important to understand and capture the information in the right context and to integrate it into an easy-to-access form through an online digital portal. Such a digital portal can help organising and providing access to the cultural knowledge in a comprehensive and systematic manner. Knowledge sources such as cultural heritage experts' knowledge and community understanding can be effectively tapped using innovative approaches such as community-based crowdsourcing.

It is unfortunately the case that some of the characteristics of this knowledge and practices (poorly documented, largely tacit and fragmented) accelerate the knowledge erosion and loss of richness and diversity of the heritage. These contribute to making the preservation project difficult despite its significance to the community. The fragmentation of cultural knowledge presents a major challenge for cultural preservation, rendering it time-consuming and labour-intensive to capture and preserve. Technological developments such as the Internet, smartphones, and advances in IT allow for a unique and crowd-driven solution to this problem. By undertaking a systematic, crowd-driven approach to gather, store, check and organise cultural information, we aim to integrate the diverse knowledge, make it widely available through an appropriate framework and platforms, and test the accuracy, validity, and usefulness of our approach to preserving and extending cultural heritage.

3.3. Objectives

The tangible cultural histories are maintained by the material form in which they are encoded, stored, and replicated. However, the cultural practices and traditions usually emerge as a kind of memory in which the public remembers and forgets the past as a lived and constantly mutating collective experience (Rosner et al., 2014). The lessons from the past should not be forgotten, and the aim of traditional knowledge management (KM) system is to enable information and knowledge that is captured in the system to be retrieved to solve future problems based on the situations and solutions of the past (dePaula and Fischer, 2005).

The main objective of this study is to develop a proof-of-concept-level digital portal prototype that facilitates multiple users to contribute on adding, sorting, refining, representing, and to enable the growth of the cultural knowledge and related-practices through the Internet. The major challenges include the understanding of the Balinese *kulkul* artefact and practices concept which arising from the poor documentation and fragmented community knowledge. The digital portal will be used as a tool to store and share large multimedia (texts, images, and sounds) contents; thus, it is necessary to have a mechanism to organise, classify, and enable the semantic relationship of the large digital cultural resources. There is also a need for an abstract representation of the domain knowledge to which an ontology will be helpful. The ontology will include the key concepts in the *kulkul* domain, their attributes, and the interrelationships among the concepts. The *kulkul* ontology was developed in consultation with selected Balinese experts and knowledgeable community members.

3.4. Design and Development

The artefact is the digital portal that facilitates gathering and accessing the relevant cultural knowledge systematically, and support semantic browsing and searching of digital resources. The design includes the development of a basic *kulkul* knowledge representation in the form of a lightweight ontology to organise and represent the knowledge and supports the semantic interrelationships among the multimedia resources. The development of the digital portal includes three modules: 1) populate content, 2) browsing facility and 3) searching facility. The design and related methods will continue to be refined based on emerging performance needs.

In our previous research, we have proposed a knowledge classification framework to capture, classify, and organise the rich of *kulkul* related knowledge, based on the analysis of the information we gathered through in-depth interviews with selected Balinese cultural experts. This enabled us to elaborate on the

key Balinese cultural principles (*Tri Hita Karana* and *Desa Kala Patra*) as they relate to *kulkul (Pramartha and Davis, 2016)*. Also, this exploratory study gave us an in-depth understanding of *kulkul* artefact in all its diversity and the related practices and to come out with *detailed* specifications and features. The *kulkul's* specification is essential to model the *kulkul* domain and to gather the raw data from the Balinese community.

In the first instance, the domain modelling was undertaken in Balinese language and Bahasa. Resource Description Framework (RDF) support for localisation (using `rdfs:label`) was subsequently utilised to support other languages such as English translations of the main modelling concepts. After analysing the transcribed interviews through thematic analytics method, we modelled the *kulkul* domain as follows:

- to be modelled as classes:
  - All entities that are families of things; for example, a family of the various kinds of temples, locations, a family of activities such as *panca yadnya*;
- to be modelled as individuals:
  - All physical entities: for example, persons, the name of *desa adat/pakraman*, banjar, raw materials;
  - all types of *panca yadnya* ceremonies: e.g., cremation (*ngaben*), meeting (*sangkep*);
  - all kinds of hazard: e.g., flood, fire, and so forth;
  - all sorts of *kulkul* beat or rhythm: e.g., *tulud*, *bulus*, *banban*, and so forth;
  - all nonphysical entities that cannot have instances or subclasses.

3.4.1. An ontology-based approach

Much of the content on the internet is designed for humans to read, not for computer programs to manipulate meaningfully (Berners-Lee et al., 2001). Ontologies are formal structures for knowledge sharing and reuse that provide a common understanding and interoperability between humans and machines and are generally developed by small groups of experts (Fensel, 2001, Gruber, 1993). Recent trends suggest that ontologies can be a useful tool to help represent and capture knowledge from the past, and manage and preserve cultural heritage resources in digital form (Doerr, 2003, Jurisica et al., 2004, Stasinopoulou et al., 2007). Ontological structures can also be applied to better digital information retrieval, and to improve the user search when looking for primary sources (Lin and Davis, 2010).

The well-known cultural ontology CIDOC-CRM (Doerr et al., 2006) was used as the basis for the ontology development. Less than five percent of its concepts have been used by museums (Doerr and Iorizzo, 2008), and the CIDOC-CRM is too museum-centric (Brownlow et al., 2015). We developed the basic *kulkul* ontology based on the *kulkul* knowledge classification framework mentioned above. Our ontology development adopted the Pinto & Martin (2004) method of ontology development workflows (Figure 3), which consists of five phases (specification, conceptualisation, formalisation, implementation, and maintenance) and three activities (knowledge acquisition, evaluation, and documentation). Given the nature of our project, we did not strictly follow its workflows and phases and employed a modified iterative and incremental approach.

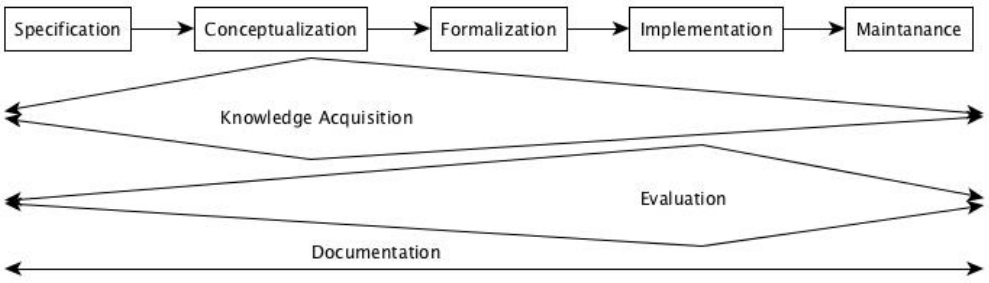

Figure 3. Ontology development workflows

The *kulkul* ontology (Figure 4) provides an abstract representation of the knowledge surrounding the *kulkul* domain. The ontology also assists the users of the prototype to effectively search the system that we develop, and formal reason can be applied while the knowledge is evolving. In this study, the knowledge acquisition, evaluation, and refinement employed crowdsourcing (described in more detail

in section 3.4.3 below). The crowdsourcing aspect helps to reduce blind spots by integrating the views of multiple persons about various topics to achieve greater comprehensiveness and to enhance the probability of acceptance of the ontology by the community. The key *kulkul* concepts or classes, properties, relationships, and example instances were created using the protégé[1] ontology editor, and the ontology representation OWL2 language.

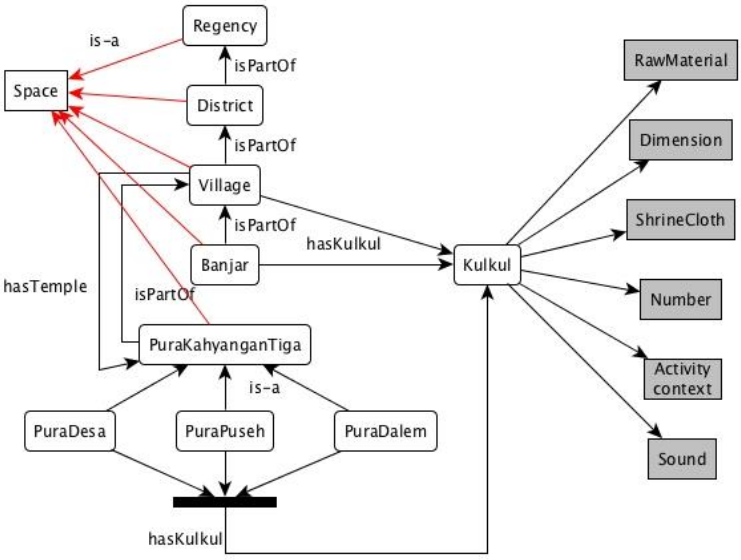

Figure 4. Part of the kulkul ontology

Here is a sample of the OWL representation in Turtle triple syntax serialisation (ttl) for easy readability to represent the space (*desa*) of our ontology. The `rdfs:label` localisation is used to support other languages (e.g., English, Bahasa, and Balinese). Further, transitive properties (`isPartOf`) are used to express the relationship between individuals in the classes of *banjar*, *desa adat/pakraman*, district, and regency:

```
@prefix thk: <http://dpch.oss.web.id/Bali/TriHitaKarana.owl#> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
thk:BanjarAdatUbudKaja rdf:type thk:Banjar , owl:NamedIndividual ;
thk:hasKulkul thk:KulkulBanjarUbudKaja;
thk:isPartOf thk:DesaPakramanUbud .
    thk:DesaPakramanUbud rdf:type thk:Desa , owl:NamedIndividual ;
    thk:hasKulkul thk:kulkulDesaPakramanUbud;
    thk:isPartOf thk:KecUbud .
    thk:Desa rdf:type :Class ;rdfs:label "Village"@en , "Desa"@id .
thk:KecUbud rdf:type thk:Kecamatan , owl:NamedIndividual ;
thk:isPartOf thk:Gianyar .
thk:Kecamatan rdf:type :Class ;rdfs:label "District"@en, "Kecamatan"@id.
   thk:Gianyar rdf:type thk:Kabupaten , owl:NamedIndividual.
   thk:Kabupaten rdf:type :Class ;rdfs:label "Regency"@en ,
   "Kabupaten"@id ; rdfs:subClassOf thk:Space .
```

To perform a semantic search to find all *kulkul banjars* that belong to Gianyar regency, we can execute a SPARQL query against the RDF triple store based on the *kulkul* ontology by utilising the SPARQL 1.1 property path expression "`isPartOf*`":

```
SELECT DISTINCT ?kulkul
{?banjar a thk:Banjar; thk:hasKulkul ?kulkul; thk:isPartOf* thk:Gianyar. }
```

[1] http://protege.stanford.edu/

We have populated the fields of regency and district, and these data were collected and extracted from the Indonesian post office database. We expect to retrieve the data for *desa adat/pakraman*, *banjar*, and *pura kahyangan tiga* from the Bali Province government; however, they did not have accurate and complete data.

3.4.2. Digital Portal

The prototype digital portal is implemented on the cloud to facilitate elastic growth and easy user access to the resources to both reads and to add content. The virtual server is equipped with an Intel Core i3 CPU, 2 GB of RAM, and 35 GB of hard drive. Running on CentOS 6.8 64-bit (Final release) with command line interface only, Apache and Nginx as a web server, Mysql for database management, and Apache Jena as the RDF triple store. Fuseki[2] was used as a middleware layer to interface our web application with the ontology. In addition to that, the EasyRDF[3] API was used to provide a PHP API to Fuseki. The browsing results are retrieved and displayed using JSON and AJAX calls. This digital portal relies on the *kulkul* ontology that serves as a backbone and knowledge classification to support the semantic browsing and searching facilities of our system. The Google Maps API v3 was applied to point the exact location of *banjar* and *desa* where each *kulkul* is installed. The latitude and longitude data was sourced from the Google Maps API and stored in the *kulkul* ontology. We employed Vesta[4] as the control panel to manage the server services and to carry out periodic backups.

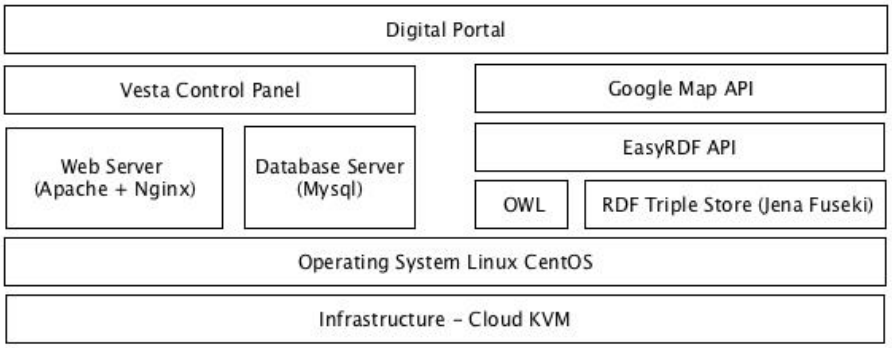

Figure 5. Digital portal architecture

The online digital portal prototype is currently under development and can be viewed at http://ccbp.oss.web.id/. All the three modules (populate content, browsing, and search) have been implemented. The portal is conceptualised to be a living resource with more content to be added by members of the community in a moderated setting.

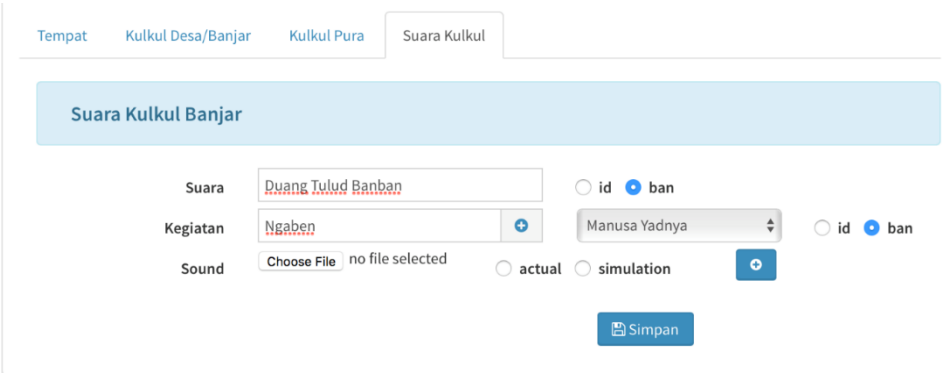

Figure 6. Populate content module: kulkul practices

The multimedia resources (images and sounds) are stored on a conventional file server, with their filenames being referenced within the ontology (Figure 7).

[2] https://jena.apache.org/documentation/serving_data/
[3] http://www.easyrdf.org/
[4] http://vestacp.com

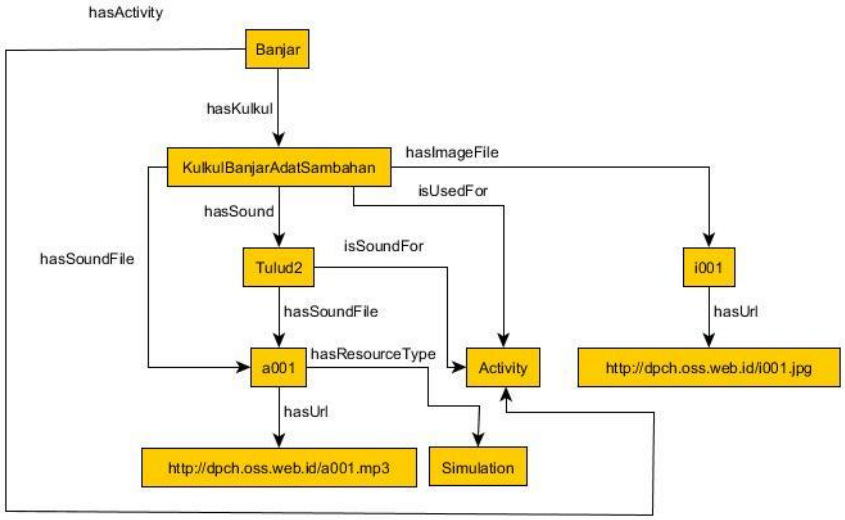

Figure 7. Multimedia storage linked to the kulkul ontology

3.4.3. Knowledge Acquisition

Crowdsourcing is a method of acquiring the contributions over the Internet from the wider public to help to solve complex problems. Crowdsourcing for cultural heritage projects typically have not involved large crowds; most reported cases have been relatively small collaborations with carefully chosen informants (Oomen and Aroyo, 2011). This type of crowdsourcing uses social engagement techniques and encourages a sense of public ownership and responsibility where the volunteers do not feel taken advantage of because the projects in cultural heritage are non-profit making (Alam and Campbell, 2012, Carletti, 2011, Owens, 2013). Additionally, in the cultural domain, the participants are not looking for monetary rewards and tend to be motivated by sharing and generosity (Daniels et al., 2014).

In Bali, there are nearly 1,500 villages, around 3,600 *banjars*, more than 5,000 temples that have all installed *kulkul*. Documenting the unique and diverse *kulkul*-related knowledge and practices is time-consuming and labour intensive. Accordingly, there was a strong case for a community-based crowdsourcing approach to our digital heritage project to help capture the diversity and richness of the community's knowledge about Balinese *kulkul* across different villages, *banjars*, and temples in the island of Bali.

We focused on tapping the community' knowledge by gathering the relevant information as it pertains to *kulkul* artefacts and practices from across different geographical regions. The creation of large-scale structured digital cultural resources was in the form of raw data such as recordings of *kulkul's* sound and images. This kind of information had to be first digitised before it could be submitted into the digital portal.

We ran the knowledge acquisition study from October 17th, 2016 to January 30th, 2017 at two different campus locations in Bali (Denpasar and Jimbaran). Participants were recruited from student and staff network of two universities in Bali (Universitas Udayana and STIMIK/STIKOM Indonesia). The Universitas Udayana was chosen for the research because of its reputation as a repository of Balinese cultural knowledge and expertise. STIMIK STIKOM Indonesia was selected because the Schools of Information Technology is one of the largest in Eastern Indonesia, with more than 2000 students currently enrolled in this school. The majority of students and staff from the two universities are Balinese people. Posters were placed around the university campus with a brief overview of the study and the contact details of the researchers. It was not a requirement of this study, however, that a participant must be a student or staff member of the university to participate. The only requirement of this study was that participants must be at least 18 years or older at the time of the research, and have knowledge about Balinese *kulkul*.

84 people responded to our invitation; however, only 78 of them (49 students from Universitas Udayana and 29 students from STIMIK/STIKOM Indonesia) finally participated in the study. They were 60 males and 18 females, aged between 19 and 23 years old, and came from four different religions (Hindu, Muslim, Christian, and Catholic), with the majority being Balinese Hindu. More than half of the

participants (51 participants) were members of the local Balinese community, the Balinese orchestra group (*sekehe gong*) and the Balinese youth community (*sekehe teruna teruni)*.

Data collection was carried out using our digital portal prototype and an online questionnaire was used to assess the usability of the portal. The study was broken into several sessions or days, for us to be able to improve the performance of the system when the participants reported bugs. Before the study started, participants were provided with instance data that will be needed to be inserted into the digital portal. Also, each beginning of the sessions, a member of the researcher team spent about 20 up to 30 minutes to give an overview of the project and using an overhead projector explained and illustrated how the system works. After the introduction and small session of training, the participants were asked to populate further details of Balinese *kulkul* using multimedia data (text, images, and sound) on the online digital portal, and then they have been invited to answer a small set of questions regarding the usability of our digital portal.

The participants were required to populate details of space or location, such as regency, district, *desa adat/pakraman*, *banjar*, and *pura kahyangan tiga (pura desa*, *pura puseh*, and *pura dalem*). Further, they were asked to extract and describe the *kulkul* artefact and their knowledge of practices based on its location (*desa adat/pakraman*, *banjar*, and *pura kahyangan tiga*). The *kulkul* artefact information consisted of the number of *kulkul* installed in every location, raw material, size and dimension, the direction of its hole, whenever there is more than one *kulkul* mounted in a place of *bale kulkul*, a recent picture of the *kulkul*, and *penggangge*. *Penggangge* is a cloth that adorns altars and shrines that are often used to decorate the shrine's *kulkul*. *Penggangge* typically has colours of white, yellow, black, red, and *poleng* (a combination of black, grey, and white)

The information related to *kulkul* practices comprised the name of its beat (e.g., *a tulud bulus*, *duang tulud banban*, and so forth.), its use for any activities (e.g., meeting, marriage, cremation, hazard, and so forth.) and the participants were asked to classify these activities into *panca yadnya* or hazard. *Panca yadnya* is how Balinese people classified the ceremonies in Bali: 1) for Gods, 2) for priests, 3) for an ancestor, 4) for humans and 5) for an evil spirit. Finally, the participants were requested to upload the *kulkul* recording sound, whether it was an actual or simulation sound.

Following completion of the knowledge acquisition in this study by the participants, the *kulkul* ontology evolved significantly from 1543 to 10403 triples. Using the protégé ontology metrics tool, we determined the following numbers relating to the *kulkul* ontology evolution (Table 1).

Metrics	Before	After
Axiom	1,438	10,301
Logical axiom	726	7,416
Declaration axioms	402	1,818
Class count	99	104
Object property	45	46
Data property	29	30
Individual	227	1,634

Table 1. Kulkul ontology metrics

4. Demonstration and Pilot Evaluation

After developing the proof-of-concept-level digital portal prototype, we demonstrated the digital portal to selected users and communities by letting them use and experience the digital portal, followed by an extensive evaluation. This study was approved by the University Human Research Ethics Committee. The users' perception on the usability of the digital portal was collected by asking them to answer a small set of questions. At this point, 66 volunteers (49 males and 17 females) from 4 religions (50 Hindu, 10 Muslim, 4 Christian, and 1 Catholic) responded to the questionnaires, and 95% of the volunteers reported that they had been using the Internet for more than one year. The instrument was translated into Bahasa using the back-translation method (Brislin, 1970) to ensure the reliability of the instrument in the different language.

We adopted the questionnaire constructed by Koohang (2004), which comprises 12 variables (simplicity, comfort, user-friendliness, control, readability, adequacy/task match, navigability,

recognition, access time, relevancy, consistency, and visual presentation). The variables are measured in 7-point Likert scale (strongly agree = 7, agree = 6, somewhat agree = 5, neither agree nor disagree = 4, somewhat disagree = 3, disagree =2, and strongly disagree =1). Moreover, participants were invited to add further comments and suggestions if they wished.

4.1. Data Analysis and Results

The following statistical analyses were conducted using SPSS:

- Reliability test (Cronbach alpha) was carried out to find internal consistency among the items.
- One sample T-test was conducted to determine whether the system is perceived as usable.

The reliability of the items was assessed with Cronbach's alpha. The calculated alpha was 0.875, which is above the minimum threshold of 0.7 (Nunnally and Bernstein, 1994). Hence, the reliability is deemed sufficient.

The statistical result indicates that the users' perceived usability of the digital portal score (Mean = 5.71, SD = 0.65,) was statistically significantly higher than middle point of 4.0 ($t(65) = 21.383$, $p = 0.00$). Moreover, the result suggests that generally the users perceived the usability of the digital portal to be positive.

The individual users' comments were recorded within an online questionnaire that was given to the volunteers. Their suggestions were used for further improvements to the module, user interface and digital portal, which we have subsequently made: for example, displaying the error message to the user whenever any problem appears during the use of the digital portal.

5. Conclusion

We have presented the details of our research dealing with one aspect of Balinese culture, the Balinese traditional communication system (*kulkul*). Our contributions include the development of *kulkul* ontology to represent this knowledge, and the development of a digital portal prototype to enable the sharing and growth of knowledge related to the Balinese *kulkul*.

Our study involved 78 volunteers in a community-based crowdsourcing from two universities in Bali to contribute more details to our first module of the digital portal prototype and basic *kulkul* ontology by classifying, refining and updating community cultural resources that are mainly available on the Balinese community social system. This community-based crowdsourcing feedback will be used to expand the *kulkul* ontology and to enhance the digital portal.

We are currently working on making the *kulkul*'s multimedia resources available online for particular groups of users to evaluate the usability and usefulness of our digital portal prototype to enable them to undertake the browsing and searching tasks.

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