Digital Repository of Information and Knowledge - Fund "BellKnow"

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Abstract. The aim was to develop an archive containing detailed description of church bells. As an object of cultural heritage the bell has general properties such as geometric dimensions, weight, sound of each of the bells, the pitch of the tone as well as acoustical diagrams obtained using contemporary equipment. The audio, photo and video archive is developed by using advanced technologies for analysis, reservation and data protection.

Keywords: Bells, Cultural heritage, Knowledge Technologies and applications, Multimedia digital archives, Steganography, Computer science

1. Introduction

At present, Bulgaria is in a new stage of its culture and spiritual progress. Conditions for researching our common heritage and for new preservation methods development are more favorable now that Bulgaria joined the European Union.

Church bells are one of the most important parts of our cultural heritage. As a historical object the bell has general properties such as geometric dimensions, weight, etc. and one very specific property – its sound. That is why we create an archive that contains records of the sound of each of the bells, acoustical diagrams, videos and images obtained using contemporary equipment.

Collection of information is done by different specialists (engineers, mathematicians, computer scientists, historians, accredited bells assessors, etc.). For this operation are passed many sites using the following special equipment:

- Audio recording – specialized audio equipment;
- The photo and video equipment – specialized HD cameras SONY;
- Measurement of dimensions - laser meter, digital meter, etc.

The aim of the Knowledge - Fund "BellKnow" is to do research and identification of valuable bells located in churches and monasteries and create archive using modern technologies for analysis, storage and protection of audio information. We develop semantic web and ontology system of unique Bulgarian bells.

We also consider the problem of authorship authentication and signing of RDF graphs. We use these results to create RDF graphs signing procedure and apply it to the ontology system of unique Bulgarian bells.

In this article we present digital archive of unique Bulgarian bells and method of signing of RDF graphs fragments in semantic web of digitalized materials. To accomplish this we have to:

- Create and analyze digital archive of unique Bulgarian bells;
- Develop semantic web and ontology of digital resources;
- Signing RDF graphs fragments in semantic web of bells.

A complete environment for Semantic Web Communities (the DBin platform) and ontology of digital resources and signing of RDF graphs fragments in semantic web is given in detail in [2], [11-12].

Developed methodology is applied in the project "Research and Identification of Valuable Bells of the Historic and Culture Heritage of Bulgaria and Development of Audio and Video Archive with Advanced Technologies" (BELL) [1-3], [5]. In our research we also consider some experience in the same area and we use several techniques for creation and analysis of digital archives and libraries in [4], [7-9], [10].

2. Documentation and Passportization

The aim of the project “BellKnow” was to develop an archive containing detailed description of church bells, as well as to develop a digital archive (using advanced technologies) for analysis, reservation and data protection. To accomplish this we have to document the main bells' characteristics: design, form, type, geometric size, decorative and artistic scheme, weight, material, state, characteristics of chime, data about the producer and owner of the bell, estimation of its historical value. So, in case that unexpected circumstances destroy a bell, the archive will keep the specific details to be investigated by different specialists.

This requires:

- To document the main features of the bells: type, geometric size, decorative and artistic design, weight, material, condition, features in the sound, the manufacturing and owner assessment of historical value;
- To make digital photographs of the bells and videos during their beat;
- To analyze and record the frequency spectrum of the bells at the moment of impact;
- To analyze and record the frequency spectrum of the bells in the established prime etc.

Based on these and other data we prepare a passport model for each test bells. This passport could be used to document the future of all existing bells in Bulgaria. Passports are summaries of all the information gathered about an object, in this case several sets of bells in one place. This includes photographs, historical reference, technical data, charts and research done in the electronic version of the passport – embedded multimedia files with recorded audio and video clips.

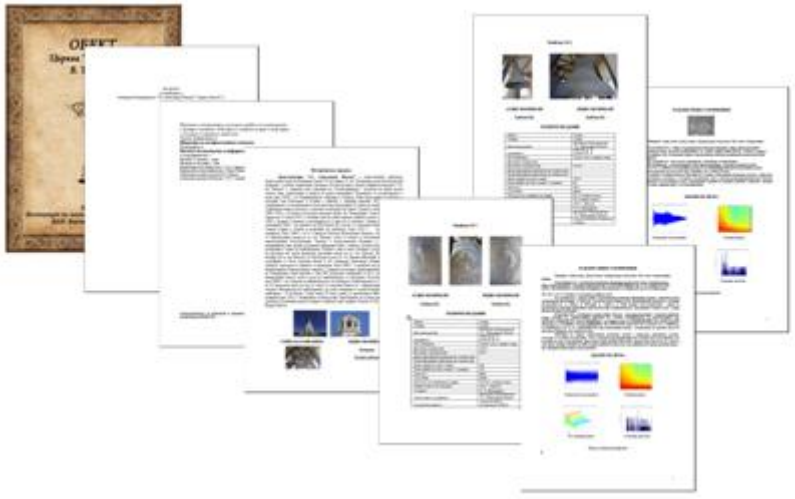

Fig. 1. Passport bells in a historical place.

This passportization is a publication of all data collected from various studies in a document. The document includes sections in which information is divided into:

- Home page of the document and location of the bells;
- Page with a presentation of the draft study and identification of church bells in Bulgaria;
- History of the location of the bells (monastery, church, museum, etc.);
- Scheme of the bells of a given place;
- For each bell following data is included:
  - Picture materials;
  - Technical data shown in the next scheme (dimensions, location, type, material, year and place of creation, creator, etc..);
  - Art Design of the bell (historical data, captions, pictures, decorations, ornaments, etc.);
  - Data from sound analysis, supported by diagrams;
  - Digital recording - video clips and sound recordings.

	District/Settlement	Bulgaria
	Country	Veliko Tarnovo
	Place	Preobrajenski monastery
	Coordinates	42°39'16.88" N 23°16'15.22" E
	Type	Church bell
	Material	Bronze
h_{out}	Height (outside) (cm)	45
h_{in}	Height (inside) (cm)	42
t_{low}	Max.lower thickness (cm)	3.6
t_{up}	Max. upper thickness (cm)	1
$d_{low-out}$	Lower outside diametre (cm)	54.5
d_{up-out}	Upper outside diametre (cm)	
d_{up-in}	Upper inside diametre (cm)	
	Weight (kg)	
	Condition	fair
	Pitch in the moment of stroke	
	Established tone	
	Created (year and place)	
	Creator	
	Owner	Preobrajenski monastery
	Aesthetical value	high cultural and historic value

Fig. 2. Scheme of the bell and technical data. Bell number one in Preobrajenski monastery, near Veliko Tarnovo, Bulgaria.

3. Digital Multimedia Archive "BellKnow"

Considering that there is a digital archive for unique Bulgarian bells, and there is lot of interesting information hidden in digital resources, we make an intelligent annotation of knowledge. A digital archive "BellKnow" is developed by using advanced technologies for analysis, reservation and data protection, and it contains [1], [5]:

- The main bells' characteristics: design, form, type, geometric size, decorative and artistic scheme, weight, material, state, characteristics of chime, data about the producer and owner of the bell, estimation of its historical value;
- Digital photos and video recordings of the bells while being tolled;
- The frequency spectrum of the bells during a stroke;
- The bells' frequency spectrum after transitive process;
- Charts representing the sound fade by time, sound stream, sound pressure and other acoustic characteristics.

Organization of the "BellKnow" archive [1]:

- Digital data
  - More than 3 000 digital records with added digital stegano-graphic sign (invisible watermark);
  - Including photo pictures, video clips, audio records;
  - Technical data, historical references, passports, diagrams etc.
- Tree file structure

- Digital files format, parameters, coding;
- Specific signature for file name;
- Additional META textual data for indexing of media files:
    - Title (name of subject);
    - Creator (name of digitalizer);
    - Description (additional data);
    - Date (date of creation);
    - Type (type of media);
    - Format (file format, codec and parameters);
    - Identifier (geographic coordinates);
    - Rights (owner of property rights).

In establishing the digital archive we should keep in mind that it has a tree file structure where all objects are arranged. FotoStation program allows an archive to a multitude of primary and sub directories. The program has built in powerful file editor providing all functions needed for working with files located on a computer system.

4. BELL Ontology

4.1 Semantic Web

The most widespread standards for the description of resources are SGML, XML, RDF, OWL [13]. Resource Description Framework (RDF) is framework for describing and exchanging data. It offers a model and syntax for metadata, so that they can be used by independent components. At its core RDF contains nodes and attached there to pairs of attributes and values. Nodes can be any Web resources (pages, servers, virtually all of which can be given Universal Resource Identifier (URI), even other types of meta data). Attributes are properties of knots and their values are either atomistic (text strings, numbers etc) or other resources or meta data. This mechanism allows to build boxes (labeled directed graphs), which could later be converted into XML. We make an experimental semantic annotation, based on the current W3C Semantic Web initiative standards (RDF, RDFS, OWL [13]) of the resources in digital archive of unique bells. We use the RDF data model, because it provides a model for describing resources of bells. Digital resources have properties (attributes or characteristics of bells). RDF defines a digital resource as any object that is uniquely identifiable by an URI.

4.2 Ontology

Using information of metadata annotation we make ontology explanation of Bulgarian bells.

Next is shown a part of RDF/XML data code from developed ontology of one settlement of bell:

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«RDF:RDF»
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  «RDF:Description RDF:HREF =
"http://www.math.bas.bg/bells/bell/"»
     «bell:belfry RDF:HREF = "#belfry"/»
     «bell:media-files RDF:HREF = "#media-files"/»
     «bell:history-information RDF:HREF = "#history-
information"/»
     «bell:audio-characteristic RDF:HREF = "#audio-
characteristic"/»
     «bell:technical-data RDF:HREF = "#technical-
data"/»
  «/RDF:Description»
…
  «RDF:Description ID="bell_01_01"»
     «bell:name»bell №01 from 01«/bell:name»
     «bell:condition»good«/bell:condition»
     «bell:coordinates»42˚41’45.28’’ N 23˚19’57.36’’ E
«/bell:coordinates»
     «loc:name» Alexander Nevsky Cathedral«/loc:name»
…
     «ach:tone»Sol of great octave «/ach:tone»
     «td:out-height»172.5«/td:out-height»
     «td:in-height»163.1«/td:in-height»
     «td:weight»6002«/td:weight»
     «td:top-diameter»123«/td:top-diameter»
     «td:down-diameter»226«/td:down-diameter»
     «td:material» Lead alloy, silver and copper
«/td:material»
     «CARD:Affiliation»Home, Inc.«/CARD:Affiliation»
  «/RDF:Description»
«/RDF:RDF»
```

4.3 Singing RDF Graph

An RDF statement involves a name if it has that name as subject or object. An RDF graph involves a name, if any of its statements involves that name. Given an RDF statement *s*, the Minimum Self-contained Graph (MSG) containing that statement, written MSG (*s*), is the set of RDF statements comprised of the following:

- The statement in question;
- Recursively, for all the blank nodes involved by statements included in the description so far, the MSG of all the statements involving such blank nodes.

This definition recursively build the MSG from a particular starting statement; Theorems proved in [12] show that the choice of the starting statement is arbitrary and this leads to an unique decomposition of the an RDF graph into MSGs.

In [6] is proven that an RDF model has a unique decomposition in MSGs. The MSG definition and properties say that it is possible to sign a MSG attaching the signature information to a single, arbitrary triple composing it. Along with the signature, an indication of the public key to use for verification might be provided. By "attach" we mean by using a verification procedure. Using the same procedure more signatures can be attached to the same MSG either independently or "layered" thus providing a mechanism for countersigning.

5. Conclusion

Creation, optimization and protection of audio and video archive of valuable Bulgarian bells is an important and difficult task. Particularly significant is the role of the primary measurements of acoustic parameters of the bells. For their time each bell, except that it was a work of art also was a high-tech facility. Some of the secrets of old masters have not yet been revealed. In this sense, the authors hope their work will contribute to European values and cultural space. In this context we expect collaboration with the Institute for the Study of Europe's cultural heritage in Toulouse (France), Moscow bell centre and other institutions. The authors believe that the project is particularly useful for Veliko Tarnovo and adjacent municipalities, as some have retained exceptional monuments and history from ancient times.

In conclusion we can say that it was confirmed the adequacy of the choice of methods and formulations of measurements and photographing for the fulfillment of the goal. The next step is further determination of the details of the types, quantity and accuracy of parameters necessary for passports and passportizaiton of new and valuable bells.

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