
PROPOSAL

for the establishment of a **full-time doctoral programme**
pursuant to Art. 21(7) of the Higher Education Act

at the Institute of Mathematics and Informatics, Bulgarian Academy of Sciences
Professional field: 4.6 Informatics and Computer Science
Doctoral programme: *Informatics*

Dissertation topic:

Three-Dimensional Modelling of Cultural Heritage Objects: Methods for Creation, Semantic Enrichment, and Valorisation as Digital Twins

Proposed by: **Assoc. Prof. Vesela Statkova, PhD**

Relevance

Three-dimensional digitisation of cultural heritage objects is one of the most rapidly developing areas within the digital humanities and informatics. The advancement of accessible methods such as photogrammetry, LiDAR scanning, and neural 3D reconstruction (e.g. *NeRF*, *Gaussian Splatting*) significantly expands the possibilities for creating highly detailed 3D models of cultural assets - from individual artefacts and sculptures to architectural complexes and archaeological sites. At the same time, the concept of the digital twin, well established in the industrial domain, is attracting increasing interest in the field of cultural heritage.

Despite technological progress, significant challenges remain. There is still no established methodological framework for evaluating and selecting appropriate 3D digitisation methods depending on object type, scale, and intended use. Semantic enrichment of 3D models—their linkage to metadata, ontologies, and linked data—remains underdeveloped. Standards for interoperability of 3D content in the cultural sector (e.g. *IIIF 3D*, *3D-HOP*, *Web3D*) are still emerging, while European initiatives such as *Europeana 3D Task Force* and *CARARE* are actively working toward common frameworks for the description, publication, and exchange of 3D content.

The role of artificial intelligence (AI) in this domain is twofold. On the one hand, AI methods (neural reconstruction, computer vision, automated segmentation) are key tools for the creation and annotation of 3D models. On the other hand, semantically enriched digital twins published as linked open data become valuable resources for AI systems, enabling automated reasoning, search, and knowledge generation in the domain of cultural heritage. Linking 3D models to the Wiki ecosystem (e.g. Wikidata identifiers, Wikimedia Commons) and publishing them via specialised platforms (e.g. Sketchfab, 3DHOP, Europeana) further enhances their accessibility and reuse potential.

The proposed doctoral research is directly aligned with the priorities of the FOCUS project, particularly the areas of *Datafication of Cultural Heritage* and *AI in GLAM*. The 3D model, understood as data rather than merely visualisation, is a key component of heritage datafication. The use of AI methods for automated reconstruction and semantic annotation also situates the research within broader developments in AI for the cultural sector.

Objective of the Doctoral Research

The aim of the doctoral research is to develop and experimentally validate methods for the creation, semantic enrichment, and valorisation of 3D models of cultural heritage objects.

Research Tasks and Methods

- **Comparative analysis of 3D digitisation methods** (photogrammetry, structured light, LiDAR, NeRF, Gaussian Splatting) and development of criteria for method selection based on object type, required accuracy, accessibility, and scale;
- **Development of a methodology for semantic enrichment of 3D models**, including linkage to ontologies (e.g. CIDOC-CRM), annotation of regions and components, and integration with metadata from external sources;
- **Investigation of the digital twin concept** in the cultural heritage context and definition of a formal model describing its structure, lifecycle, and relationship to the physical object;
- **Design of an architecture for digital twin management**, including storage, versioning, access, and interoperability (using standards such as IIIF 3D, glTF, Web3D), aligned with European frameworks and initiatives (Europeana 3D, CARARE);
- **Integration of digital twins with the Wiki ecosystem** (Wikidata identifiers, Wikimedia Commons) and exploration of publication models via specialised platforms (Sketchfab, 3DHOP, Europeana) and open data portals;
- **Investigation of valorisation models**, i.e. reuse of digital twins in education (VR/AR environments), tourism (virtual tours), research (measurement and comparative analysis), conservation (condition monitoring), and the creative industries;
- **Experimental validation** through the development of prototype digital twins of Bulgarian cultural heritage objects and evaluation of the application of the proposed methods.

Expected Results

The research is expected to produce:

- a comparative evaluation of 3D digitisation methods, including criteria and guidelines for method selection depending on object type and digitalisation objectives;
- a methodology for semantic enrichment of 3D cultural heritage models based on linked data principles;
- a formal model of the digital twin for cultural heritage, describing its structure, lifecycle, relationships, and interfaces;
- a prototype architecture for digital twin management, demonstrating storage, versioning, semantic access, and visualisation;
- a set of 3D digital twins of specific Bulgarian cultural heritage objects, created and enriched according to the proposed methodology, linked to Wikidata identifiers and published via appropriate platforms;
- models and scenarios for the valorisation of digital twins across domains such as education, tourism, research, conservation, and the creative industries, including scenarios for machine consumption of data by AI systems;
- scientific publications in informatics, computer vision, digital cultural heritage, and 3D modelling.

Impact

The expected results will contribute to the development of the methodological and technological foundations for 3D digitisation of cultural heritage in Bulgaria. The proposed formal model of the digital twin and the methodology for semantic enrichment will support the transition from isolated 3D models to integrated, interoperable, and reusable digital resources.

From an informatics perspective, the research will contribute to advances in computer vision, the semantic web, and 3D data management, with potential applications beyond the cultural sector, including architecture, urban planning, and industrial design. The integration of 3D models with the Wiki ecosystem and European infrastructures (e.g. Europeana, EOSC) will enhance the visibility and reuse of Bulgarian 3D cultural heritage and the preparation of the data for machine consumption will further support future AI applications in the sector.

Affiliation

Department of Software Technologies and Information Systems (Institute of Mathematics and Informatics, BAS)

Used Research Infrastructure

- **CLADA-BG**
- **HEMUS Supercomputer**