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# 3D MODEL OF HRICOV CASTLE ENHANCED BY REAL TEXTURES

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**Abstract**

The authors present the law protection of cultural monuments in the Slovak Republic and the outputs of an interesting case study, more specifically the creation of a 3D model with real textures of Hricov Castle, which was created in 2019 with additional improvements done in 2022. Ruins of Hricov Castle are located in the village of Hricovske Podhradie, 15 km from Zilina. For model creation, devices obtained within the project of the Broker centre of air transport for the transfers of technology and knowledge into transport and transport infrastructure was used. The 3D model of Hricov Castle created by team leader Tomas Cesnek currently presents one of the most realistic Slovak digital 3D models created by laser scanning technology. This model will be a part of the permanent exhibition of Hricov Castle in the historical toll building from 1556 in Dolny Hricov, Slovakia, the reconstruction of which is ensured by the members The Association of Friends of Hricov Castle. Model creation methodology and the use of special textures should be used to produce more realistic laser scan 3D models.

**Keywords:**

Protection of cultural monuments;
Hricov Castle;
Laser scanning technology;
3D model;
Model creation methodology.

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## 1 Introduction

Analysis of surface parameters becomes an important issue not only in the architectural presentation of 3D Models. Department of Geodesy of FCE UNIZA started intensive research using the newest laser scanning technology in 2013 by measuring railway lines [1]. Afterward, laser scanning technology was applied to determine limestone quarry deposits or to scan and create 3D models of complicated geomorphological structures such as rock cliffs [2-4]. Laser scanning can be also applied to assess the roughness and friction of concrete surfaces in various engineering and geotechnical structures interacting with the ground [5, 6]. Laser scanning is being increasingly used in innovative technologies to objectify the morphology of pavement surfaces [7-9] and to create realistic 3D models of castles (Fig. 1) and historical monuments.

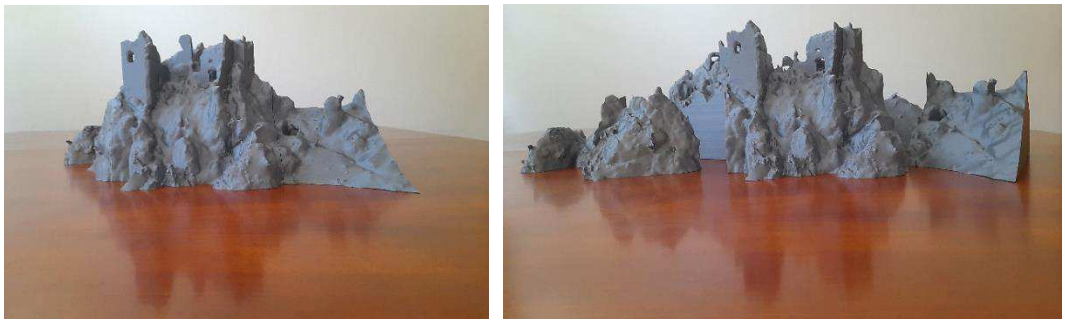

Fig. 1: Views of a terrestrial 3D model of Hricov Castle created by Ing. Tomas Cesnek in 2022. The model consists of 6 parts and 3D printing lasted a total of 170 hours.

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3D models in cooperation with the research of experts engaged in the restoration of monuments [10, 11], their technical [12-14] and environmental [15-17] protection, make a significant contribution to the preservation of Slovakia's historical heritage. Every activity in human society has some quality and form of legal regulation. Change, restoration, and reconstruction of castles and chateaux are mainly technical solutions, but they must meet strict legislative conditions. Castles (Fig. 1) and chateaux are an essential part of the cultural heritage of the Slovak Republic. Many of them have global importance as they are entered into the UNESCO World Heritage List, Fig. 2. In the Slovak Republic, the protection of cultural monuments is an important legal issue. For this reason, it is discussed in the following chapter.

## 2 The protection of cultural monuments in the Slovak Republic

In the basic legal act of the state, the Constitution of the Slovak Republic [18], the protection of cultural heritage is regulated together with the protection of the environment. From the constitutional point of view, it is systematically included in the regulation of fundamental rights. However, its content is determined in Articles 44 (2) and (3). It is possible to conclude its objective value and public interest, and not as a subjective right of a particular person, or the so-called legitimate interest. The difference between these categories is mainly in the question of who can actively advocate for the protection of such a value. If we speak of a subjective law in the case of cultural heritage, the scope of the "eligible" would be strictly defined concerning a specific person.

On the contrary, the public interest or fair value has a different nature. The essential feature of the so-called constitutional objective value is the circumstance that even the highest legislative body does not constitute it but merely provides it with the highest protection. Thus, like the environment, regardless of the legal existence of the law, in our society it is considered an objective value aside from the act of the legislator. Within the legal philosophy, we could thus understand it as the value of natural law, which does not depend on the will of the legislator.



Fig. 2: Views of Spis Castle inscribed on the UNESCO World Heritage List in 1993 [19].

However, it is necessary to move from this abstract category of legal philosophy to the normative level of the Constitution and law acts of the Slovak Republic. The already mentioned Article 44 par. 3 defines the duty of everyone to protect cultural heritage. This obligation is given in general terms without specifying the exact person of the liable party. This obligation, therefore, applies not only to persons who have a relationship to the thing, such as the owner, tenant, or user but also to all other persons who can influence the quality of the thing by their actions.

Such adjustment is also significant for other reasons. The potential damage to the object of the heritage is essentially irreversible. In Slovak law, in the General Civil Code, we already have a provision of the general obligation to prevent damages. By determining such a constitutional obligation concerning cultural heritage, the creator of the Constitution wanted to point out one of its specific features. In the event of damage to a common thing (movable or immovable), civil law foresees the possibility of compensating for damage in money. Such compensation is completely sufficient. However, in the case of the protection of cultural monuments the legal relevance is in the authenticity of the respective object. Although its faithful copy may fulfil an aesthetic significance (see the Royal Castle in Warsaw), it precisely loses the sign of historical authenticity. Therefore, much harmful interference with monuments is inherently irreversible. The second dimension of the protection of cultural monuments, in general, is the understanding of cultural heritage as a public interest. The public interest is usually a particular benefit, a positive value, which either the legislator or the court

understands as such, which can restrict subjective rights and from which the advantages of a specific indefinite group of person result. In some literature, the concept of the common good is also synonymous with the public interest. Legally, also in terms of construction work or other interventions in cultural monuments, the fact that it is in the public interest is important. It should be noted that both the Constitution and the legal acts do not look at the monument as a protected thing without the possibility of irreversible interference. However, the legislation is much stricter than for ordinary constructions, where a simple decision of the building authority is sometimes enough. In this case, on the one hand, there is an explicit competence of the state administration body in protection and care of the monument fund. That is the Monuments Office of the Slovak Republic or the individual regional monuments offices. Without their prior written opinion and in case of remediation of the decision, it is not possible to allow any construction intervention to them. Secondarily, if the intervention is approved, it is always necessary to examine the reasonableness. Either this concerns the owner of the monument, whose rights are curtailed by the opinion or decision, or the monument itself and the authorization of irreversible action (e.g. remediation).




Fig. 3: Copper engraving of Hricov Castle by J. Nypoort (1625 - 1692) from 1686 (Source: Justus van der Nypoort 1686), views of the remains of the Hricov castle from beginning, half (archive: P. Stansky) of the 20th century and the years 2020.

The basic rules laid down in European legislation on how to implement an institute of public interest should be applied. Adequacy is to be examined within the so-called proportionality test, which consists of 3 parts:

a) Existence of a legitimate purpose. This means the existence of a value recognized by the Constitution, law, or court decision, which we understand to be in the public interest. In our case, the already mentioned Article 44 para. 2a 3. As well as the Constitution, the law (i.e., legal regulation of lower legal force) explicitly understands cultural monuments as a public interest. There is Act no. 49/2002 Coll. on the protection of the monument fund [20] as amended, which explicitly mentions the public interest in paragraph 1. On the other hand, in the case of interference with a monument, there must be a legitimate reason, which is most often the immediate threat to life and health or significant property damage.

b) Subsidiarity is the obligation of public administration bodies to look for another non-innovative solution. Subsidiarity concerns both directions of decision-making of the monument body. As well as concerning the restriction of the owner, where the principle that this should be done only if it is not possible to achieve the goal otherwise applies. For correctness, it must be said that the legal regulation of the protection of monuments itself presumes the minimization of the situation when the aim can be achieved other way than by restricting the right of ownership. This rule is already enshrined in the Constitution, as we will mention later. The second direction of subsidiarity is the permission for irreversible intervention or remediation of a protected object. In this case, in our view, the condition sine qua non is to prove the impossibility of another solution that would make it possible to preserve the case.

c) Proportionality is the last step that the protection body evaluates when examining the need for intervention, either in one direction into subjective law or in the other direction in the public interest. Adequacy means "weighing" the value of a cultural monument, resp. interference with it and other rights to be limited.

The public interest is reflected in several obligations under the Monuments Act. Violation by the owner of these obligations can be considered an administrative offense with a financial sanction. However, significant damage to the sine iusta casua of a cultural monument can also be considered a criminal offense. According to the provisions of § 248a of Act no. 300/2005 Coll. [21], as amended (hereinafter referred to as the Criminal Code), a criminal offense is both damage and destruction of a cultural monument and frustration of administrative proceedings for its declaration. It is very strict

protection which also recognizes a sentence of imprisonment of 6 years for its commitment. The strictness of the legislation reacted to the case when within the process of administrative proceedings, some owners simply destroyed a future cultural monument to avoid a stricter regime of possession. According to the basic constitutional principles, ownership is binding. According to Article 20 of the Constitution, the exercise of property ownership rights may not harm cultural monuments beyond the scope established by law. On the one hand, the owner must keep the object in good condition, to refrain it from being damaged to the extent permitted by law, and at the same time, he/she has the right to dispose of the object. In the case of castles and chateaux, the issue of ownership is critical. The reason is that whether the responsibility or e.g. the use of renewal funds is usually linked to the existence of a rightful owner. The basic rules of legal protection, which we introduced above, are relatively easy to apply if the partner - the property owner - is obvious. However, in castles and chateaux, there are several possible situations when it comes to terms of ownership. An unknown owner, municipality, state enterprise, Slovak Land Fund, or even legally does not exist. Possibility to target the castle respectively other real estate and subsequently legalize it depends on the ownership of land and its legal use.



Fig. 4: Condition of the windows of the western palace of Hricov Castle before the restoration and after the restoration of 2017 [22].

This issue was partially solved by Act no. 326/2005 Coll. on forests [23], as amended, by its amendment of the year 2021. This one enabled the transfer of ownership of land on which the castle or other cultural monument is located to the municipality or higher territorial unit, based on the permit of the Board of Monument Care under the purpose of restoration and care of the monument. In addition to municipalities and higher territorial units, based on this change from 2021, it is possible to enable the use of the castles in the public interest also by civic associations. It is a special type of possession of a thing (cultural monument) based on a contract and with the consent of the Conservation Council. Both cases can be realized free of charge.

### 3 Briefly from the history and restoration of Hricov Castle

Before the presentation of the work of laser scanning application, a short introduction of the historical monument of Hricov Castle should be introduced. According to published data, Hricov Castle is mentioned in historical documents in 1265 as a castrum Hrichou, in 1271 as Hrychov, in 1272 as Herychou, in 1370 as Riczo, and in 1392 as Hrichou. The oldest information about Hricov is from 1208 when it is mentioned as the property of the Nitra bishopric and the first surviving mention of Hricov Castle is from 1265. At the beginning of the 14th century, Matus Cak Trenciansky was the landowner of the entire castle estate. In 1563, it was bought by Frantisek Thurzo, who eventually transferred the centre of the Hricov estate to the city of Bytca. The castle underwent its last building modifications in 1621 [11, 12]. The engraving of the Dutch artist J. Nypoort from 1686 (Fig. 3) reveals that the castle standing on the still unforested hill was relatively well preserved with 32 windows seen in the engraving. In 1627, the castle was acquired by Mikulas Esterhazi, and later the castle was deserted in the middle of the 19th century it was bought from the Esterhazis by Baron Leopold Popper from Bytca [22, 24].

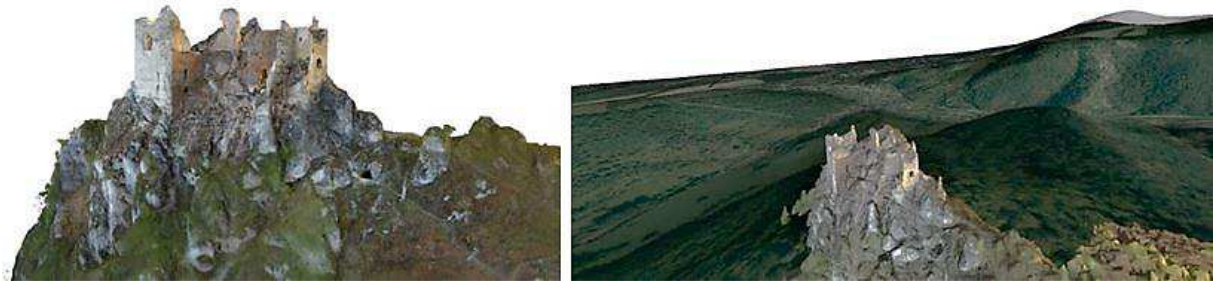

Fig. 5: 3D model of Hricov Castle after the removal of vegetation - west side from 2019 (left), enhanced model from 2022 (right) created using original and new laser scans.

The Association of Friends of Hricov Castle was established on 7 July 2010 and is dedicated to the conservation and restoration of the castle (Fig.4) under the supervision of the Regional monument institute of Zilina and also ensures the implementation of the necessary research [22].

## 4 Creation of a 3D model of Hricov Castle with a real texture

As part of the activities of the authors of the article from the Department of Geodesy, Faculty of Civil Engineering, University of Zilina, a 3D model of Hricov Castle with real structures has been in development since 2018. A multi-purpose rotary laser scanner Leica ScanStation C10 was used for the geodetic survey of Hricov Castle. Like the entire ScanStation series, the Leica C10 is a compact all-in-one laser instrument that achieves a very high 3D accuracy of scanned points thanks to a very small angular deviation and high distance measurement accuracy. These laser scanners create a dense cloud of dots by measuring the reflection of a trace of a laser beam that is scattered into space by a rotating reflection prism with Smart X-Mirror technology.

Surveying historic buildings, such as old castles, chateaux, or ruins, is a particularly demanding activity. It is mainly due to their complex architecture, which had to respect the relevant artistic styles and ideas of the initial builders. It was also necessary to deal with the frequently challenging natural conditions in which the buildings were constructed. In addition, some of these buildings have been destroyed and only partially or completely restored. The shape of such buildings is most irregular. It is hard to identify corners in places where the plaster is missing. In addition, the walls vary in thickness and are only very rarely straight or rectangular. All these aspects almost entirely preclude the use of classical surveying methods for the survey documentation of historic buildings. With the invention of 3D laser scanners, the measurement and documentation of historical objects have improved considerably. Using these devices, we can capture millions of points in a short time. Therefore, we can fully convert the scanned object into digital form, and only after processing can we create the desired outputs. Such outputs can be individual views, floor plans, sections, the detailed orientation of windows, sculptures, ceilings, vaults, etc.



Fig. 6: Model of Hricov Castle after removing vegetation - plan view of the 3D model.



Fig. 7: Model of Hricov Castle after removing vegetation - east side.

In recent years, with a significant increase in the computational capabilities of commonly available computers, the overall 3D model of an object with real textures has become a very popular output. Creating realistic textures is another advantage of 3D laser scanning of an object, as the scanner can capture not just the position of the object's points but also their colour in an RGB scheme. 3D models created in this way are commonly the basis for virtual tours, presentation videos, or materials for 3D printers.



Fig. 8: Model of Hricov Castle after removing vegetation - northeast side.

Hricov Castle was scanned in August 2018. Due to the complexity of the surrounding terrain, it was scanned from a total of 43 positions. The sites were chosen with as much overlap as possible between the individual scans around the perimeter of the entire castle as well as inside it. The total number of scanned points after the removal of vegetation and trees was 78 629 297 points. The resulting model of Hricov Castle can be seen in Fig. 5 to 9.



Fig. 9: Overview of completed 3D Model of Hricov Castle located in the cadastre of Hricovske Podhradie.

## 5 Conclusions

The paper presents the current state of legislative protection and technical rehabilitation of important Slovak monuments on the example of the ruins restoration of Hricov Castle. The legislation also regulates the question of when the castle is in technical condition if it is only the so-called torso (ruins). A torsional state or even a torsional architecture is a building, ruin, or remaining of a building that extends beyond the earth's surface. Thus, these are ruins that, although they have a de facto monumental value, are not in the register of cultural monuments. Even in these cases, the law allows their transfer or use either by territorial self-government or community in the public interest.

Slovak legislation is very strict as regards the protection of immovable cultural heritage, whether formalized as cultural monuments or as torsional architecture. Therefore, construction and maintenance work on castles, in addition to technical and financial intensity, are also legally and legislatively demanding. And it is in realistic building restoration of historical monuments that their 3D models are beginning to play an important role. The creation of 3D models of historical objects, such as castles, chateaux, churches, aqueducts, and bridges present new possibilities for their reconstruction and revitalization. On the example of good cooperation of the team of the Faculty of Civil Engineering of the University of Zilina, the Association of Friends of Hricov Castle, and representatives of the local government of the village Dolny Hricov a reference 3D model of the Hricov castle was created. This model currently represents one of the most realistic digital 3D models of historical monuments in region Zilina (castles Starhrad, Lietava, Sulov), created by laser scanning technology. The authors hope that other significant monuments will follow, where they will use their experience and contribute to the preservation of cultural heritage for future generations.

Based on the OECD research from 2020, tourism is one of the biggest and fast-growing sectors of the world economy. Tourism plays a key role in job creation as well as in added value creation. In 2018, the revenue from tourism in Slovakia totalled EUR 2.7 billion, which the mentioned refers to 3 % of GDP. The authors [25] focused their attention on identifying some marketing communication tools' impact on visitation of the castles in Slovakia. This study shows that the perception of the quality of the implemented offline marketing communication activities has a considerable influence on the interest of customers in revisiting castles.

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