Progressive Non-Destructive Digital Methods in the Research of Small Sacral Architecture in Czech and Slovak Republic

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Abstract. Historical architecture is without doubt a valuable part of cultural heritage. Various methods, predominantly non-destructive and progressive should be used to analyse, document, monitor, maintain and to prepare any remediation activities. 3D models as an output of photogrammetry are one of these. Paper deals with analysis and comparison of the two, visually similar small chapels in two different countries. Authorship of each is verifiably documented and belong to different well-known architects – in the first case - chapel at Svatý Hostýn, Czech Republic – it is Dušan Samuel Jurkovič and in the second case, Chrasť, Žilina, Slovak Republic it is František Bednárik (Bednářík). Digital model compares and confirms almost identical volume and measurements of the details of the architecturally designed part of the mentioned small sacral buildings.

1. Introduction

Small crosses and small sacral monuments are part of the so-called small architecture. The oldest preserved are medieval, but most of them dominate the landscape and urban space since the Baroque period. The tradition of creating sacred ways that pass through significant nodes continues in the next periods in many forms, including not only calvarias. The minor sacral architecture also includes the ways of shrines, crosses and smaller chapels with places of silent contemplation.

The article deals with a pair of such sacred localities. The first site is one of chapels of the Way of the Cross at the important Moravian pilgrimage site on Svatý Hostýn by architect Dušan Samuel Jurkovič, built in the years 1903 – 1905. The second location is a small chapel of Our Lady of the Seven Sorrows, built at the outskirts of Žilina on the hill Chrasť, designed by architect František Eduard Bednárik in 1928.

Both works already show a significant degree of conformity during visual inspection. Older, sooner built chapels on the St. Hostýn are clearly in line with the context of Jurkovič's work with roots in the folk architecture of the Carpathians. By contrast, Bednárik's chapel in Žilina is inconsistent with the architectural features of architect's rondocubist buildings or the vast majority of his International style buildings. Likewise, this chapel with distinctive art nouveau features is clearly outside the stream of modern, International style works in Žilina in the 1930s.

The article is the result of the first phase of research of both sacral buildings, consisting of: analysis of mass composition and formal composition using progressive non-destructive technique – 3D model constructed. The second stage is carried out simultaneously with the evaluation and publication of the conclusions of the first stage of the research. The second stage include research of archival materials,
biography and the whole creative work of both authors, which will probably bring more light into the problem of visual conformity of both works.

2. Dušan Samuel Jurkovič (1868 – 1947)

Dušan Samuel Jurkovič was born in Turá Lúka (today a part of town Myjava) in 1868. His family (rural intellectuals, father was a notary) had relatives that include some of the important Slovak writers, journalists, politicians, organizers of Slovak cultural life, e.g. Svetozár Hurban Vajanský and Jozef Miloslav Hurban. Dušan Samuel studied in Brezová pod Bradlom, in Sopron (today in Hungary) and in Wien at the National School of Industry. [1]

His life-long inspiration was folk architecture and folk ornament, transformed by art nouveau influence into original and unique Jurkovič's Aesthetics. His buildings in this early phase are easily detected, carrying the common motifs like wooden constructions with simple and subtle woodcarving (often painted), ceramics, ornament and flowing curves of roofs inspired by half-hip roofs and other folk motifs from Slovakia and Morava regions.

In 1899 Jurkovič moved to Brno where he designed his own house (villa in Žabovřesky, 1906), a new school lodging house and many other now famous buildings. Wooden buildings, designed and built for the touristic club Pohorská Jednota Radhostě in Pustevny were the first extensive project for Jurkovič. He designed several of this richly decorated log buildings inspired by folk architecture of Valašsko region.

Luhačovice spa was the next huge project - Jurkovič was chosen to design renovations and new buildings included in the completely new redesign of the spa plan in 1902-1903. Not all of his 20 designs were really built and Jurkovič has to leave design for Luhačovice spa to others, but he designed some private villas for Luhačovice later on.

Until the outbreak of WW I. Jurkovič worked on many other designs, e.g. Culture House in Skalica (1904-1906) and buildings in Modra, Ružomberok and Trnava (some of the for Evangelical Church). Jurkovič owned brickworks in Trnava from 1914 and from this time, he starts to incorporate ideas about prefabrication and standardisation of building materials into his designs. During the World War I. was Jurkovič a member of War Graves Unit, designing tombs and cemeteries at many localities mainly in today’s Poland.

After the war, he returned to newly founded Czechoslovakia and settled in Bratislava. His creative work changed to the new areas - he became the Commissar in the newly established Government Commission for the Protection of Monuments in Slovakia 1919 and he left this office in 1922 and returned to creative architectural work. Historic buildings and monuments remained a part of his activities - but e.g. his project for renovation of Zvolen castle (1925-1926) wasn’t executed. Later buildings carried the signs of the new atmosphere in architecture - the international style with its strong stress on functionality without ornament - Hospital for Dr. Koch in Bratislava (1929-1939) and Stations for funicular railway in High Tatras (1936-37). The World War II. meant for Jurkovič the return to tombs and monument designs, some of the them were built after the war - cemetery and tomb in Kremnička (1947). In 1947 Jurkovič died, still working on his designs of prefabricated small brick houses, much needed for families after the war. [1]

2.1 Svatý Hostýn pilgrimage site in Moravia, Czech Republic

Svatý Hostýn (Saint Hostýn) is a Moravian hill (Czech Republic) known as an important pilgrimage site with a legend of the miracle made by the Virgin Mary. Famous feature is the spring of "holy water", covered in the chapel, dated 1620. Hostýn pilgrimage site was therefore called also "Moravian Lourdes". Site was occupied and fortified from circa 1200 BCE, built, destroyed and rebuild many times. Complex on Hostýn consists of many buildings (chapels, Calvary, hostels, shops and restaurants for pilgrims etc.) dominated by the baroque Basilica of the protective Virgin of Mercy from the 18th century – figure 1.
Svatý Hostýn has two open-air Calvarias [2]. The first one, built in the beginning of the 20th century, got a lot of criticism as a boring, not artistic enough. Therefore, Jurkovič was invited to create a new chapel of the Cross Way. Matica svatohostýnská, a voluntary organization created to renovate and maintain pilgrimage site, chose him because of his famous designs of various buildings in the Luhačovice Spa. Folk art motifs gently wrapped into art nouveau dynamism were incorporated also in his open-air altars and chapels on Hostýn. Jurkovič created plans for chapels, proposed redesign of the whole Svatý Hostýn with a new complex of the shops and renovation of the Basilica. Magnificent plans stopped the outbreak of the WW I., but at least 13 of the chapels were built.

Small sacral buildings flow on the slopes of the Hostýn hill’s summit, directing pilgrims from the 1904 (see figure 2). Ceramic mosaic scenes of the Cross Way, designed by painter Jano Köhler, decorate chapels. Mosaics replaced the first scenes by painter Joža Úprka, painted on glass, which suffered in the harsh Moravian weather extensive damage and had to be removed (only one is still at the site). Ceramic mosaics were prepared and installed in 1912 – 1933.

2.2. The Chapel No. II. of the Way of the Cross
Calvary at Hostýn consists of several types of chapels – 3 roofs variant, 1 roof variant and a monumental stonework wall variant with altar covered by small saddle roof. No chapel has an interior space. All have only open-air altars on the stone staircase pediment.
The second Chapel No.II of the 13 chapels was chosen for the 3D model (see red arrow in figure 1.), because its structure and composition covered by three saddle roofs with decorative gable is the most corresponding to the chapel in Žilina. Chapel II. stands near baroque Basílica on the meadow with a very little vegetation around, that made a photogrammetry easier. The building was completed in 1919 by metal plaque with relief from sculptor Vosmík commemorating World War I victims. Relief was not a part of original Jurkovič’s design.

3. František Eduard Bednárik (1902 – 1960)
František Eduard Bednárik or Bednařík (1902 - 1960) came from Moravian village Bystřice pod Hostýnem. Born in a family of many builders, his education aimed for a work in a family business. After graduating from the College of Architecture and Civil Engineering in Prague in 1923, he worked in his father’s company. At the same time, he continued his education to an engineering degree at the Czech Technical University in 1930.

In 1923, however, he came to Žilina, small but rapidly developing town in Slovakia [3]. He participated in the construction of terraced houses (row townhouses) of Czechoslovak legionnaires carrying the features of rondo cubism with massive simple volumes. Bednařík founded his own construction company in Žilina in 1925 and worked also as an independent architect [4].

He founded a family here, and after 1939, he signed his projects usually with the Slovak transcription of his name as Bednárik. He collaborated with a number of prominent Slovak architects - F. Čapka, M. M. Scheer and F. Faulhammer. Bednárik later owned a business company (the quarry Dubná Skala and the asphalt mining company near Varín) and worked in Žilina until his death in 1960 [3].

Throughout his work from the 1920s, Bednárik belonged among a progressive International style architects, [5]. The International Style was a significant and prominent building style dominating the construction in Žilina around 1930. Žilina was a busy transport hub, a rapidly developing settlement especially in connection with the development of the industry brought by the new railway. A number of prominent architects worked here, mentioning e.g. Friedrich Weinwurm and Vécsei from all of them. ([6], p. 90, also see [7]) Perhaps the most famous building is the Žilina Neolog Synagogue by Peter Behrens, built 1928 – 1931 [6, 9].
3.1. The Chapel of Our Lady of the Seven Sorrows, Žilina – Chrášt
Chrášt' location was at the beginning of the 20th century beyond the development of Žilina town. The first building built here was the wooden Folkmann cottage (1925), an art nouveau inn [8] [9] - an important and frequently visited place for year-round trips to the town's inhabitants, especially young people, craftsmen and workers. The hill above the town with a beautiful view soon gained its first sacral place - a small stone building without an interior space, only with a niche for the statue of the Virgin Mary. A group of Žilina people built it nearby to the Folkmann’s inn.

Figure 3. Plan of the the position of the Chapel of Our Lady of the Seven Sorrows, Chrášt, Žilina

Another small sacral building - the Chapel of Our Lady of Sorrows - was built after the requests of believers to commemorate the Žilina people, victims of World War I. [10] They demanded a place that would have an interior for serving masses. Drawings for the building are dated to 1928 and marked by the name of the author - architect František Bednářík. [11]

Figure 4. View of the Chapel of Our Lady of the Seven Sorrows, Chrášt’, Žilina and right a mosaic of St. Augustine signed J. KOE 31 (Jano Köhler 1931)
In the context of Bednárik's consistently modern creations, the chapel in Chrast is a distinctly different anachronism, using the ornamental, poetic features of the art nouveau style. The richly carved architecture of the portico dominates the front view, carrying a roof with a sub-structure, a gable finished with a cross as a clear reference to the Carpathian folk architecture. However, the surrounding area of Žilina and the neighbouring region of Kysuce characterize the folk architecture of simpler shapes. Its cottages with small window openings use woodcarving only in small ornaments of door lintels and they have usually no portico. Even for the most important buildings - chapels or churches - there are no such highly decorated facades and no striking coloration, which is rather a sign of Moravian buildings.

The front facade of the Chapel of Our Lady of Sorrows covered with a quarry stone embedded with a pair of ceramic mosaic images symmetrically on the sides of the door. On the left is probably the figure of St. Augustine and on the right is St. Tomas. Jano Köhler is the author of the mosaics on the chapel in 1931 (the mosaics bear the KOE sign and the name of the company that made them RAKO – see figure 4).

A simple mass, rectangular in plan, finished with a semi-circular conclusion follows behind the decorative front façade on a multi-stage pediment. The interior, equipped with an altar with a sculpture, is otherwise architecturally as stark as the exterior of the back - relatively simple plinth and smooth white walls. A pair of narrow horizontal windows with stained glass windows illuminates the space, designed by F. Šmilauer, professor of art at the Žilina School of Real Estate. [12]

4. Photogrammetry and comparison of the two 3d models.
An engineering discipline of Photogrammetry is heavily influenced by developments in computer science and electronics. The ever-increasing use of computers has had and will continue to have a great impact on photogrammetry. The discipline is in a constant state of change, shifting its methods from analogue to analytical and digital methods [13].

In this time is very popular to take a photo with cell phone. Most of them are equipped with high-resolution CCD cameras with high quality lens. The several hundreds of photos are stored on flash memory. They are available for further processing and analysis. Another advantage is the increased spectral flexibility of digital cameras - ultraviolet or infrared photos are available. Drone cameras can help to cover also some parts not readily visible when standing at the ground level – e.g. roof surface, towers etc. Drones can be freely bought at a cost-effective price, there are however limits applied by legislative (Act No. 143/1998 Coll. on Civil Aviation (Civil Aviation Act) and on Amendments of Some Acts). All drone flights have to fulfil certain conditions and have to be approved by Transport Authority (state administrative body established in 2014). Digital photogrammetry - mainly using only smartphone camera - is a very time and cost effective method of 3D model creations, although it has some limitations and problems [14].

4.1 Processing and 3d Models creation
Object shots are taken from multiple positions. By default, images are taken incrementally around the object and a snapshot is created during movement at the stops every 2-3 meters.

Processing was in the program Agisoft Metashape, an advanced image-based 3D modeling software for creating professional quality 3D models from still images. Based on the multi-view 3D reconstruction technology, it operates with arbitrary images. Photos can be taken from any position, providing that the object to be reconstructed is visible on at least two photos. Both image alignment and 3D model reconstruction are fully automated. The processing procedure includes four main stages.

- Camera alignment. At this stage, Metashape searches for common points on photographs and matches them, as well as it finds the position of the camera for each picture and refines camera calibration parameters. As a result is a sparse point cloud, a set of camera positions, and cameras calibration parameters.
• Generating dense point cloud. This point cloud may be edited and classified,
• generation of a surface: mesh and/or DEM
• After the surface is reconstructed, it can be textured, and can be generated as an orthomosaic.

The first object was a Chapel No. II. Of the Way of the Cross at Svatý Hostýn – see figure 5. A camera Panasonic LUMIX F330 was used for this project. There were 84 photos taken and the resulting dense cloud has 2.6 million points.

![Figure 5. Model of the Chapel II. At Hostýn](image)

The second object was the Chapel of Our Lady of the Seven Sorrows, Chrášť, Žilina. A Panasonic LUMIX F330 camera was also used. A total of 192 shots were taken. The resulting dense cloud has 3.4 million points – see figure 6.

![Figure 6. Model of the Chapel at Chrášť, Žilina](image)
Various monochrome colours have been assigned to the generated point clouds of the two chapels for comparison purposes. The proportions of comparable parts of the architecture as well as the volumes of individual structures, their composition and shape were analyzed.

![Figure 7. Section of the both point clouds and ground plan comparison. Chapel in Žilina in red, chapel at Hostýn in blue.](image)

Obviously, both the volume and the dimensions of the architecture are almost identical – see comparison in the figure 7. The differences are only in insignificant elements, such as the slope of the roof gable - the chapel in Žilina has a sloped edge covered with ceramic roofing, Jurkovič's chapel in Hostýn has an edge almost horizontal. Minor differences are also in the colours used on woodcuts - the Hostýn Chapel is more richly decorated and uses green, yellow and brown in combinations. The chapel in Žilina has also white coatings, but it is questionable to what extent it is a primary coat/colour. On the chapel in Žilina there are missing metal ornaments encasing the concrete plinth of the wooden pillars of the portico.

5. Conclusions
In principle, it can be stated that Jurkovič's proposal was primary, original, and architecturally agrees with the context of his entire work. The architect Bednárik clearly used a distinctively Jurkovič's design
and modified it by adding an architectural volume with a simple interior space. A substantial part of the chapel’s expression is made up of Jurkovič’s design; Bednárik’s intervention is merely utilitarian, implemented in accordance with the inhabitants’ demand for worship space. The chapel is an anachronism at the time of construction in 1929 and is also unrelated to the ideas and architecture that Bednárik proposed at the time (e.g. [15]).

Archive research should provide more information on how this transmission has happened. Then it will probably be possible to get answers to the questions to what extent could be Bednárik’s design marked as a plagiarism - appropriation of a substantial part of Jurkovič’s work, and whether Jurkovič knew about the chapel in Žilina. An interesting topic for further research is the personality that joins both of the two works - the mosaic’s author Jano Köhler.

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