3D MODELLING OF SILK ROAD ARTEFACTS AS A TOPIC FOR REMOTE PROFESSIONAL STUDENT VOCATIONAL INTERNSHIPS DURING THE COVID-19 PANDEMIC

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Abstract

The paper presents the concept of carrying out internships with the use of electronic communication means (remote work) starting from: (1) preparation of the thematic areas of the internships, (2) their selection by students, (3) determination of the methodology of their realisation, (4) preparation and configuration of the computer equipment in the laboratory, (5) selection of tools, up to (6) practical realisation of advanced projects concerning 3D computer graphics, 3D modelling and reverse engineering and (7) the method of their completion. Students could not prepare these projects at home on their own equipment due to the lack of licence for the software used and the high hardware requirements of the software used. The procedure in question was applied to the implementation of remote work placements, in the area of widely understood 3D computer graphics, by full-time and part-time students of the 1st degree of Computer Science at the Lublin University of Technology (LUT). The students carried out projects related to processing data in the form of a cloud of points from scanning initiatives in the Silk Road area to the characters that can be presented in the form of digital 3D models, omnidirectional panoramas and virtual reality. The data made available were obtained by the employees of the Department of Computer Science during scientific expeditions organised in 2017-2019 to Uzbekistan, Kazakhstan and Kyrgyzstan.

Keywords: Apprenticeship, 3D graphics, Silk Road, remote working, COVID-19 pandemic.

1 INTRODUCTION

The global pandemic of the COVID-19 infectious disease caused by the SARS-CoV-2 coronavirus has hit a vast majority of European countries in every part of the lives of nations, local societies and individual occupational groups. One of these areas was the education system. In order to stop the spread of the pandemic, the authorities of most European countries ordered almost complete closure of educational facilities (primary schools, colleges and universities) for pupils and students [1-2]. In order to ensure continuity of the curriculum, university authorities have implemented a system of transition from traditional to remote teaching, where classes were held online [3-13]. Some universities offered asynchronous classes in which teachers prepared tasks or recorded lectures and students were able to do them at their own pace [6-7]. It was also common to teach in a system of "synchronous" classes, which took place at a certain time through an electronic medium. There is evidence to suggest that online learning during a pandemic has benefited students [14-15].

Regulations due to the spread of the pandemic have also introduced restrictions in various areas of social and economic life. This has made it more difficult, if not impossible, for students to complete their apprenticeship. However, the Polish ministry responsible for supervising education at universities (MNiSW) provided the university authorities with information reminding them that apprenticeships are part of the education process, they are obligatory, and supervision over their implementation is the competence of the university. Thus, Polish universities have been obliged to prepare and carry them out.

In connection with the situation within Computer Science (1st degree) run by the Faculty of Electrical Engineering and Computer Science, an alternative solution was introduced, which made it possible to achieve the learning outcomes assigned in the study programme to the internship. This solution consisted in remotely conducting substitute classes during which practical projects were carried out by students under the supervision of academic teachers.

The present work concerns the remote internship realised within the scope of application of 3D computer technologies. The aim of the work is:

- presentation of the idea of carrying out internships via electronic communication means,
- description of the use of computer programs and resources available in the Department of Computer Science,
- presentation of a selection of projects carried out by students during the internship.

2   PREPARATION OF INTERNSHIPS IN THE REMOTE LEARNING SYSTEM

The procedure prepared for the implementation of remote apprenticeships by 1st degree IT students included the following activities:

1. preparation of thematic areas of internships,
2. choice of subjects by students,
3. determination of the methodology of the practice,
4. preparation and configuration of computer equipment in the 'Lab 3D' laboratory,
5. selection of programs and tools for implementing specific projects,
6. practical implementation of individual projects by individual students and the way in which the effects of their work are reported.

2.1   Formal and organisational issues

The basis for conducting activities concerning the organisation of professional practice in the remote system was the information provided by the Vice-Rector for students, which appeared in a uniform form in the Rector's Ordinance, No. R-58/2020 [16]. The internship was to last 4 weeks, which in practice gave a total of 80 hours of student work (4 weeks x 5 days x 4 hours).

The Dean of Students' Affairs responsible for the IT faculty appointed a coordinator for remote internships and prepared relevant regulations and documents sent to the faculty staff, which formalised the following issues:

- appointing persons (tutors) to run remote internships,
- submission of practice topics,
- recruitment of students for internships,
- contact of the trainee supervisor with students,
- provision of materials for the projects,
- reporting on practices,
- crediting the apprenticeship by the mentor.

These provisions have structured the issues listed in points (i), (ii) and partly in point (vi).

Employees from the Department of Computer Science prepared more than 100 practice topics, which belonged to different thematic areas: multi-criteria optimisation methods, software development via different programming languages, processing of data from the motion capture system, processing of eyetracking data, using 3D computer technologies, etc.

2.2   Remote apprenticeship in 3D computer technology

The topics of practices in the field of 3D computer technology concerned issues related to the application of computer graphics tools to create digital 3D models of real objects (post-processing of point clouds from 3D scanning), as well as digital reconstruction of damaged museum objects which can then be presented in the form of digital models as virtual museum exhibits (VM), or in virtual reality (VR). Three-dimensional scans of real museum objects came from the area of the Silk Road (Uzbekistan, Kazakhstan and Kyrgyzstan) made during expeditions organised in 2017-2019 [17]. The topics of practices in this area were prepared by employees conducting research works in the Laboratory of Intelligent Systems Programming and Computer 3D Technology ('Lab 3D'), Department of Computer Science. It was assumed that they were formulated quite generally, but contained basic information about the project and referred to the method of designing inquiry-based learning [18].

2.2.1 Choice of topics

The topics of the projects and their short description were placed by the remote practice coordinator on the Moodle platform in a course called "Remote Work Experience". In addition, the course provides a detailed schedule and relevant documents to be completed and submitted. The information about their availability was sent to the students by e-mail to their university and placed on the website of the faculty, university and student government. The project topics in the course were added using an original module, which automatically sent an e-mail to the internship coordinator and the person submitting the topic at the time of its selection by the student. The e-mail included the student's name, surname, field of study, year and degree and their contact e-mail address. In order to ensure the conditions for maintaining a high level of quality of projects implemented by students, the principle was adopted that one employee could accept up to 4 students for the placement. When the limit of people to one employee was met, the system blocked the possibility of further enrolment. Students were given a set time to choose their subject. After exceeding the deadline for the selection of subjects, the system deactivated.

2.2.2 Student-tutor communication and remote connection to the computer in 'Lab 3D'

During the remote apprenticeship, the students made remote contact with the trainee supervisor. This made it possible to monitor the implementation of their work and help them solve problems. MS Teams platform was used for communication. Information about the first meeting was provided by the supervisor to the students by e-mail (the date and time of the meeting and a link so that they could join it were provided). The first meeting was of an organisational nature. The students were presented with the course of the internship and the meeting schedule (it assumed two 1.5-hour meetings per week with fixed hours). Moreover, the internship tutors discussed the specificity of work on the implementation of projects, assigned individual project tasks, discussed them, presented the scope of responsibilities, and gave computer programs necessary to perform project tasks. Students also received data for remote connection with university computers in the 'Lab 3D' laboratory (ID and password), on which they could perform project tasks. In many cases, students were not able to carry out assigned projects on their own computer equipment due to the lack of a license for the software used and the high hardware requirements of the software used. Figure 1 shows how the tutor communicates with the students and how to connect with the university computer while carrying out remote work placements.
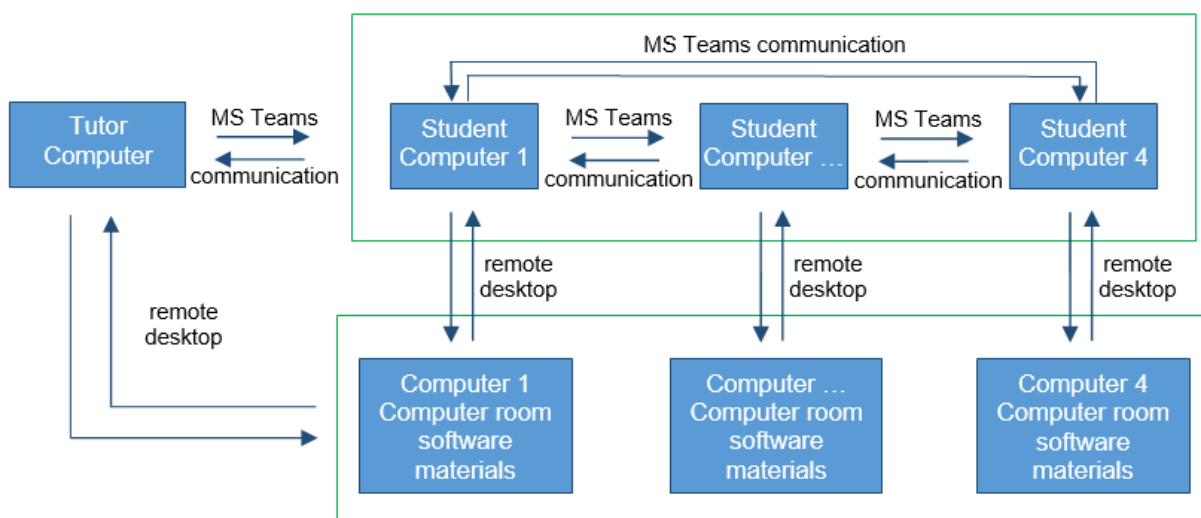

Figure 1. Scheme of connection and communication with the university computer during the implementation of remote work placements.

During subsequent meetings, each student presented the progress of their work. They also had the opportunity to ask questions about it or present problems related to it. During the meetings, the students had the opportunity to share their desktop, thanks to which they visually presented the progress of their work in front of their supervisor and other participants. Due to the fact that each of the students was assigned a different task within the project, it allowed to present the application of different ways and tools for their realisation. Thanks to this solution, each person in the group could present his or her position on a given topic. If the students had a problem with the implementation of

the task, the whole group could join in and reflect together on the solution to the problem. In this way, as an additional result of these meetings, the students' social competences were developed. If someone had an idea, they could take over another person's desktop and present it to solve the problem. In a situation when the students were not able to solve a problem, the desk could be taken over by the trainee supervisor.

2.3 Configuration of the server platform and laboratory workstations

2.3.1 Server and Moodle platform configuration

During traditional teaching, the employees of the Department of Computer Science used the Moodle educational platform to support the teaching process. The application allows to create and manage online courses. The employees have used it to conduct classes in all fields of study at the Faculty of Electrical Engineering and Computer Science (Faculty of Computer Science, Electrical Engineering, Mechatronics and Biomedical Engineering). The platform was installed on Centos 7 System, which worked on a VirtualBox virtual machine. All programs were run on the Dell R520 server, whose main parameters are:

- 32 GB RAM,

- 2 x Intel(R) Xeon(R) CPU E5-2430,

- 6 600GB HDDs using a 3.5-inch 3.5-inch rpm 6Gb/s SAS interface (drives connected in RAID 5 on the PERC H710 controller),

- 1 Gb/s public network throughput.

After switching to remote teaching, some problems with the operation of the Moodle platform appeared (slow operation, lack of connectivity, delays, etc.) due to increased network traffic, transmission of large amounts of data, a large number of participants using the platform at one time and launching the chat module for communication between students and teachers. In connection with the above, activities were carried out to improve the work of the platform, which consisted, among others, of:

- creating an additional server (with parameters as above) – on it, the second Moodle platform was launched, which was used only for remote classes in the field of Computer Science (this allowed to share the network traffic and relieve the burden of the previous platform),

- increasing RAM in both servers to 128 GB,

- switching from SAS HDDs to SATA 2TB HDDs – although SATA drives are slower, they are much cheaper and more capacious, thus also eliminating the failure of SAS HDDs,

- reinstalling the base system on servers on Ubuntu Server 18.04 LTS,

- moving the system and Moodle platform from VirtualBox to more efficient LXC containers,

- changing chat settings from Ajax (default) to Normal,

- modifying mysql and Apache configuration files.

The above-mentioned activities positively influenced the proper functioning of the server and thus the Moodle platform itself. It has improved the teaching process as well as contributed to the smooth and correct implementation of remote work placements by IT students.

2.3.2 Configuration of laboratory stands

In order to ensure the possibility of remote professional practice in the field of 3D computer technology in the Department of Computer Science in the 'Lab 3D' laboratory, computer workstations were prepared, which worked 24 hours a day. This allowed students to connect with them remotely at a convenient time and carry out assigned projects. Appropriate computer programs were installed on these computers to enable them to perform tasks. TeamViewer was used for remote connection. Each student was assigned a separate computer station and could only connect to it. He received login data (computer ID and password) at the first remote meeting with the trainee supervisor, which took place on the MS Teams platform. The supervisor was able to connect with all computer workstations.

3   STAGES OF THE REMOTE STUDENT PRACTICE

The Department of Computer Science LUT conducts scientific research on the use of 3D technology in the aspect of cultural heritage protection. This results in extensive cooperation with museums and cultural centres. Scientists deal with 3D scanning of selected archaeological artifacts, creating their digital models for their protection, digital reconstruction and creating virtual shows. Digital 3D models are a kind of documentation that enables the reconstruction of the real dimensions of shapes and textures of the artefacts. This allows for their reconstruction in case of destruction. It was decided that the practical aspects of these efforts should be included in the process of remote practice.

Each student was assigned individual materials for the implementation of the project as part of the remote apprenticeship. These were files in the form of a point cloud, which came from 3D scans of real museum objects from the Silk Road area (Uzbekistan, Kazakhstan and Kyrgyzstan). They were placed on the hard drives of university computers with which the student connected remotely. The files were large in size (2-5 GB).

3.1   Organisational activities

3.1.1   Development of a practice plan

In order to systematise the activities performed by students, each tutor together with the student prepared a plan of remote practice, which included the following activities:

- a schedule of meetings between the students and the tutor and a timetable for the performance of individual activities by the students,
- getting familiar with the assigned project task and analysing its implementation,
- getting acquainted with the selected software intended for the assigned task,
- carrying out an analysis of available tools for the assigned project task.

3.1.2   Providing materials and technology for the project

Students used programs installed on computers in the 'Lab 3D' laboratory in the Department of Computer Science LUT to perform design tasks in the field of 3D computer technology:

- Artec Studio 12 – basic software cooperating with Artec 3D scanners. Used in the scope of: data acquisition obtained from the 3D scanning process, point cloud processing, data processing and optimisation, folding of scans, creation of mesh models, texture overlay, export to other programs for further processing.
- 3ds Max – 3D modelling software. Used for digital reconstruction of 3D models, texturing and mapping and creating visualisation.
- MeshLab – is a 3D mesh processing software, which is oriented to the management and processing of unstructured large meshes. It is used for processing and optimisation of mesh models, preparation of models for 3D printing.
- Gimp – a program for processing raster graphics. Used for the preparation of textures and their modification.

In addition, the students received an electronic methodological guide, which in the first part presented the basic activities of the Artec Studio 12 program. The program is a specialist program and is available only in licensed versions, which means that it was not previously known to the students. The guide presented how to deal with point clouds. The second part included a description of the basic tools of the 3ds Max program, which are necessary to reconstruct the mesh model of the reconstructed object, in particular to smooth out walls and cracks, remove unnecessary fragments, duplicate existing wall fragments and place them in their target location so that they fit in with the rest of the object, combine the obtained meshes, smooth the surface. In the third part, the tools of the Gimp program, which allows to prepare and edit the texture and to apply the texture on the reconstructed 3D mesh model.

3.2   Project implementation

Before starting the practical implementation of the projects, the students became familiar with the literature. They analysed the items in terms of using computer software tools for point cloud

processing [19-21], the process of modeling 3D mesh objects with particular emphasis on reconstruction [22-23], creation and modification of texture [24], overlaying textures on the reconstructed 3D model [25] and methods of reconstruction of museum objects of vessels [22, 26].

3.2.1 Student 1. Digital reconstruction of a 3D model of an antique ceramic plate

The ceramic plate is dated from the 11th to the 18th century, and comes from southern Kazahstan. It was found in the medieval town of Tortkul'tobe, which is now called Sharapkent.

The student had the following partial tasks to perform:

7 building a 3D digital model from the provided point cloud, Fig. 2,

8 reconstruction of missing parts of the object, Fig. 3a,

9 creation of textures for mapping the surface of the object after reconstruction, Fig. 3b,

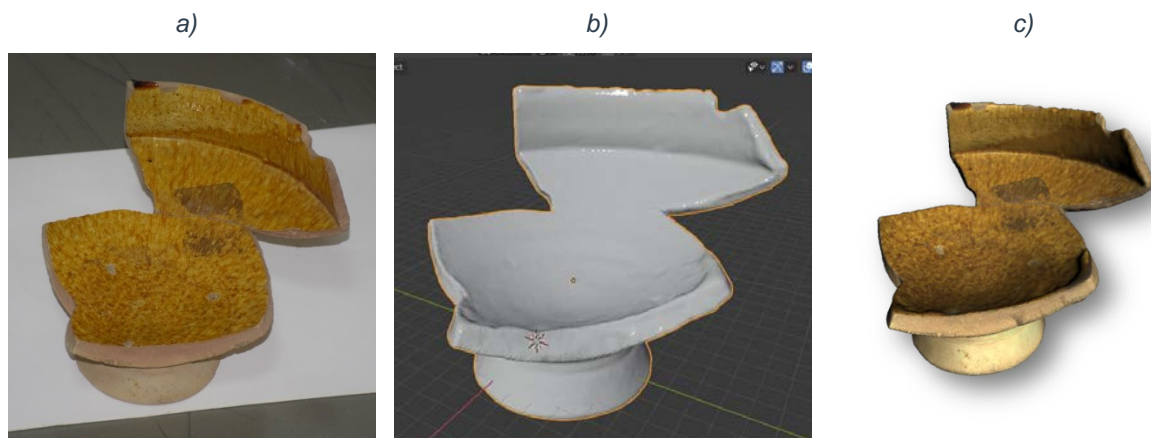10 preparing a final report on the work carried out.

Figure 2. Ceramic plate: a) photograph of the object before 3D scanning, b) digital 3D model after transforming and merging point clouds, c) digital 3D model with superimposed texture.
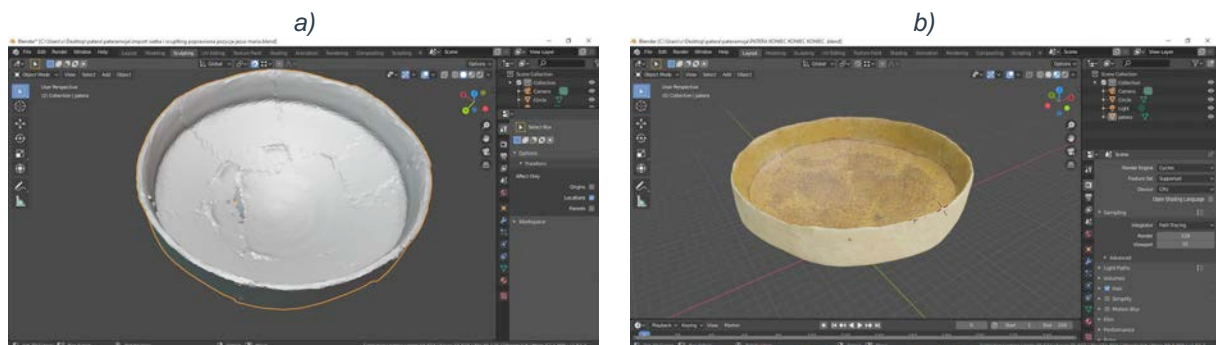

Figure 3. a) model with visible connections, b) 3D model with superimposed texture.

3.2.2 Student 2. digital reconstruction of a 3D model of a historic jug

The object under reconstruction was a broken pitcher from the turn of the 11th and 12th century, which was found in the Afrasiab excavation area. Afrasiab (Uzbek Afrosiyob) is an ancient city lying on the "Silk Road", inhabited since around the 5th century BC until the beginning of the 13th century when it was ravaged by the Mongol invasion. It is currently located on the northern outskirts of Samarkand and is an excavation area close to 200 ha. [17]..

The student had the following partial tasks to perform:

11 generation of a 3D digital model from the provided point cloud, Fig. 4,

12 reconstruction of the bottom and side wall of the object, Fig. 5a,

13 creation of textures for mapping the surface of the object after reconstruction, Fig. 5b,

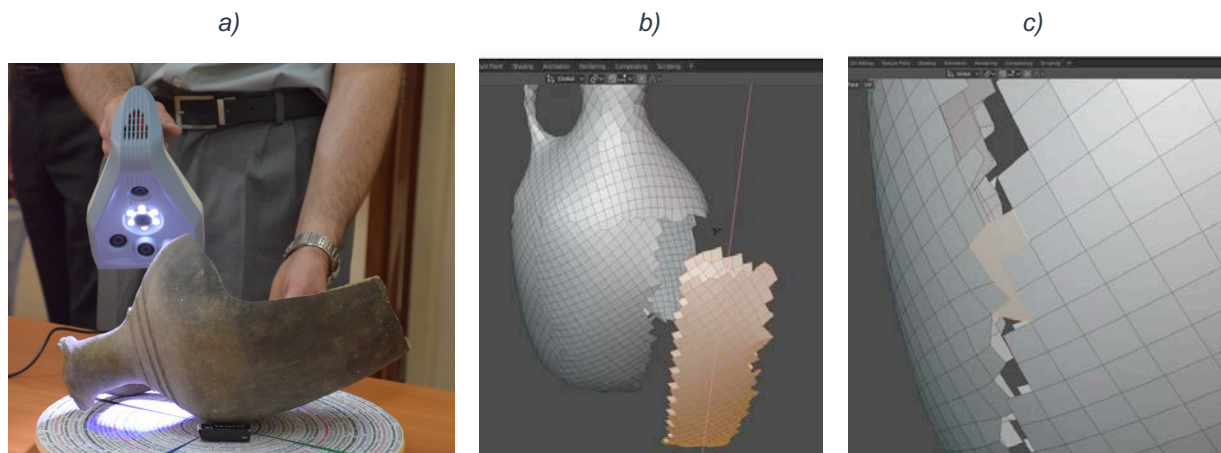14 preparing a final report on the work carried out.

Figure 4. Clay jug for water: a) 3D scanning, b) retrieving a fragment of the jug wall to be pasted – view with a visible mesh, c) surface after pasting the missing fragment – visible mismatches.
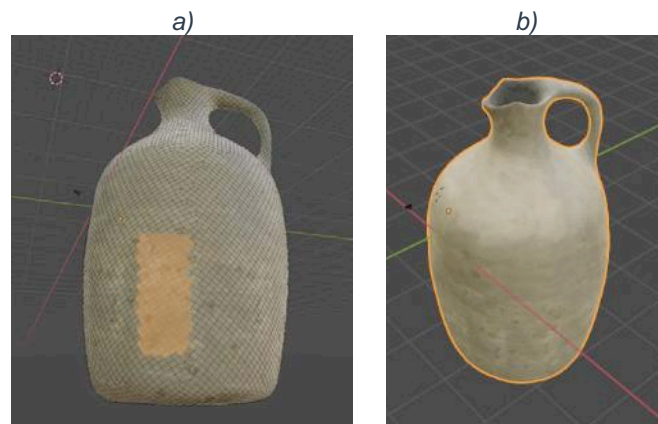
a) b)

Figure 5. Clay jug after reconstruction of its geometry: a) view of the mesh and the texture applied on the inserted fragment, b) surface after the texture applied.

The reports on the projects performed included short descriptions of actions with particular emphasis on the tools used in the process of reconstruction of the damaged vessels and printscreens, which represented the actions performed.

4 CONCLUSIONS

The remote internship with a group of students allowed the following opinions to be formulated:

- The implemented concept of remote internship has proved to be an effective solution which, despite the existing pandemic, has enabled all the didactic goals assigned to 1st degree studies in Computer Science to be achieved.

- The computer resources, the technical means available to carry out communication between students and tutors, as well as the software available at the disposal of the Department of Computers Science and 'Lab 3D' were sufficient to perform the tasks set.

- The prepared didactic materials for the execution of the projects turned out to be very helpful, which accelerated the independent solving of tasks by the students.

- The use of electronic means of communication to analyse emerging problems in the group of all students led by the tutor and a joint search for solutions was a procedure which built a social bond between the students and contributed to their more effective work.

- The prepared procedure for the implementation of remote internships can also be successfully used to conduct projects and scientific research during the preparation of bachelor's and master's theses.

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