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Research Article

Creating a partial 3D model in selected biological areas using a small number of photographs

Ondrej Takáč*[,1], Norbert Annus[1], Melinda Nagy[2], Daniel Dancsa[2] and Iveta Štempeľová[3]

[1]*Department of Informatics, J. Selye University, Slovakia*
[2] *Department of Biology, J. Selye University, Slovakia*
[3]*University of Veterinary Medicine and Pharmacy in Košice, Slovakia; Masaryk University, Czech Republic*

(takaco@ujs.sk) Email of the corresponding author

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Abstract **–** Currently, we are registering a great boom in computer technology, which allows us to use ICT techniques and procedures even in those areas in which it was not common. One such area is the creation of partial or complete realistic 3D models of real bodies in biology - in our case, trees or wood. Their great advantage is that they can capture various cases of growth deformations, interesting shapes or atypical formations. Many are temporary and unstable. An example can be a wood rotting fungus. These can then be studied outside the place of their growth and at the same time preserved for future comparisons. This leads to another possibility of their use in the educational process. We must also point out that a real 3D model with preserved dimensional proportions and true colors is a much better solution for studying than a classic photograph. We use photogrammetry to create 3D models. Its great advantage is that the 3D model is created from a series of photos that capture the part of the real object from which we want to create a partial 3D model. A classic touchscreen mobile phone is enough to get these photos. However, many problems and complications are associated with the creation of 3D models. It is not always possible to get quality photos. This can be caused by e.g. height, terrain or other obstacles. To obtain the desired partial 3D model, it is ideal if several conditions are met when obtaining photos, such as overlapping photos, sharpness, color, visible texture, etc. But in real cases it is not always possible to achieve this and therefore in our contribution we focus on the subsequent processing by which we can achieve our goal - even under the aforementioned unfavorable conditions to create a 3D model.

Keywords – Photogrammetry, 3D models, Pix4D, Tie-points, Biology

I. Introduction

Models in general are currently very widespread and in practice bring many positives. Some are listed, for example, in: [1-4] 3D models are also a very good tool for analysing different growth forms on trees. In addition, they are very beneficial for supporting interdisciplinary relationships, whether between informatics and biology or even mathematics [5-8]. Advantageously, we can also use UAVs when obtaining photos. They are especially suitable in those cases in which the objects are in inaccessible places, at heights, rocky places, etc. [10-12] Drones are no longer completely new even in the educational sphere. It is advantageous to use them in secondary schools, where we can focus on the use of various HW electronic components, for example Arduino and simulation environments, for example Tinkercad. [20-23]

In the educational field, the creation of 3D models can be interesting for both students and teachers. It makes it possible to encourage students' interest in biology and STEM subjects in a playful way. In addition to working in the computer lab, students can also participate in photo collection, where they can also participate in field work, which is especially appropriate in the subject of biology. [14-19] [24-27]

II. Materials and Method

Often the reason why a 3D model could not be created is that the photogrammetric software could not use all the photographs and excluded some of them from the creation. Such photos are usually marked in red, which is what we see in our case. We specifically used the photogrammetric software pix4D to create the 3D model - see. Figure 1. This is a very good tool for creating 3D models with which we have already achieved many positive results in the past. If the software discards some photos, the 3D model may be incomplete. In this case, the part of the model from which the photos were missing is usually missing. In such cases we have to try to manually add the discarded photos. One option we can use with advantage are Tie-points. By adding manual Tie-points we may be able to add some photos. We do this by selecting tie-points on photos that have already been processed by the software (they are marked in black) that are clearly visible even on photos that have not been processed by the software. By manually marking these points on the photos and adding them, we then re-run the Local processing (blue quadrilateral in Figure 1), which will result in a new 3D model but with the Tie-points already processed.

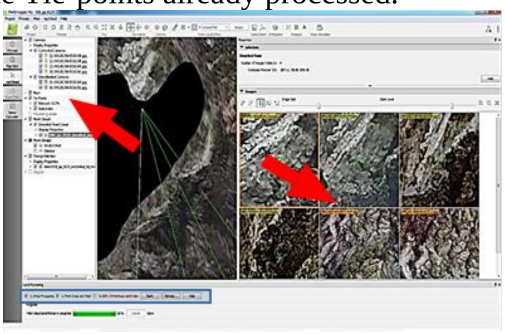


Fig 1 Example of marking discarded - unused photos for 3D model creation in Pix4D environment window

However, these procedures can also be used when part of the desired 3D model has not been created, i.e. when the model is incomplete. We will show this with the following concrete example. In Figure 4, we see the marked part on the trunk of the tree from which we want to create a partial 3D model. So not the whole trunk, just the part we are interested in. This is an older tree that has very nicely healed pruning wounds, and it is one such wound that is the focus of our interest. Let's just say that in collecting the photographs, only a very small number could not be obtained. The minimum number of photographs from which a 3D model of sufficient quality can be constructed is 3. In our case we have only one more photograph, 4, which we also show in figure 4. Normally, such partial models are created from ten, up to several dozen photographs. We can see that already at the beginning we have a not ideal starting point for the creation of a 3D model. As a counterexample, we see in Figure 2 a well-crafted 3D model of a trunk from several dozen photographs taken at a single height.

Fig 2 Sorbus aucuparia L. 3D modell. Available for download at: https://skfb.ly/ozPJH

It is also good to see another problem, namely that the photographs were taken from the ground. In this case we did not have the possibility of using a UAV so the overlay will not be perfect. The last photo is even without significant contrast. These complications then lead to the creation of a partial 3D model of which a significant part may be missing and, as can be seen in our example, is missing.

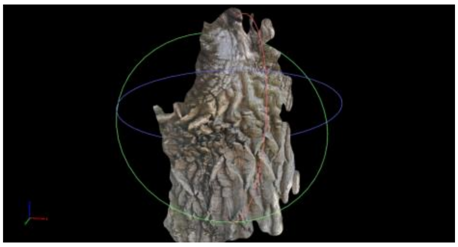


Fig 3 Created 3D model

So the natural question is, how many Manual Tie-points are needed? There is no clear answer. It all depends on the task at hand. In our practice we have worked with models that did not need Manual Tie-points but also models where this need amounted to several tens of Manual Tie-points. Certainly, it happens that some model or sub 3D model cannot be created. That is why it is a challenge. This often happens, for example, when obtaining photographs against the sun.

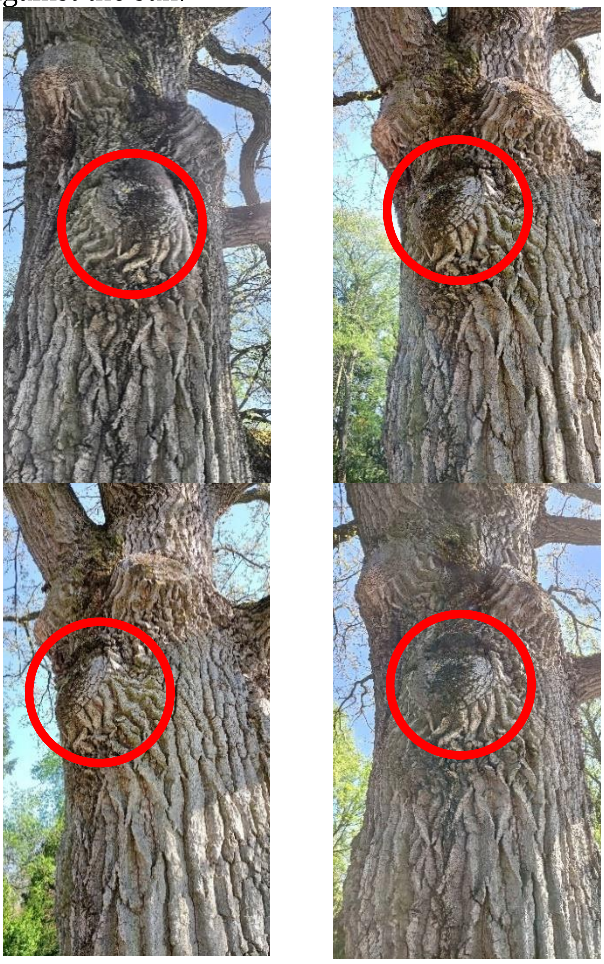


Fig 4 Photographs serving as a basis for the creation of the 3D model

We can describe the model by several parameters, which, in connection with the required number of Manual Tie-points on a specific example, we will present in the results of this work. In total, we used 21 Manual Tie-points to build the model before we were able to obtain the desired fraction. We show the location of the Manual Tie-points in Figure 5. Manual Tie-points 7, 3, 8, 2, 15 and 6 are located outside the desired part. The point in the middle without reference is Manual Tie-points 14. When choosing Tie points, we tried to select most of the points in the desired area.

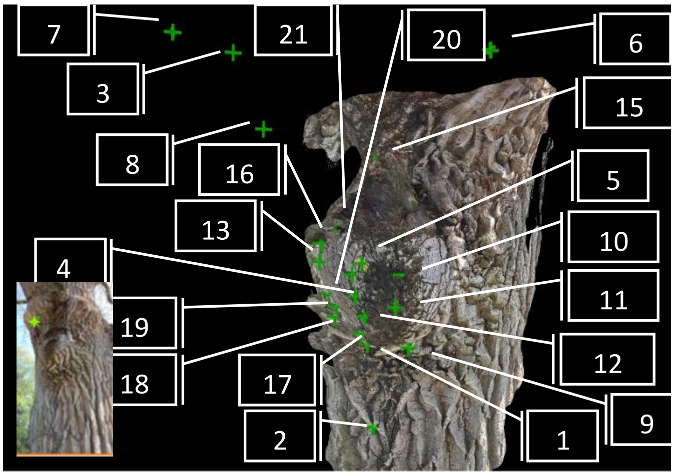


Fig 5 Tie-points location and specific example for Tie-point 3

III. Results and Discussion

In table number 1, we list frequently observed statistical indicators when creating a 3D model using a different number of Tie-points. With the increasing number of added manual Tie-poits, we see that the Number of 3D Points between two photos does not change significantly. But we can see a slight increase between the four photos. It is clear that their number has doubled.

But the difference is noticeable between Number of 3D Densified Points (No3DDP). In picture number 6, it is clearly seen that by adding manual Tie-Poits (MaTP), their number grows. In our case, the following applies to these increases:

$$No3DDP = -68{,}817 \cdot \mathrm{MaTP}^2 + 6005{,}7 \cdot \mathrm{MaTP} + 94611$$

Where $R^2 = 0{,}905$

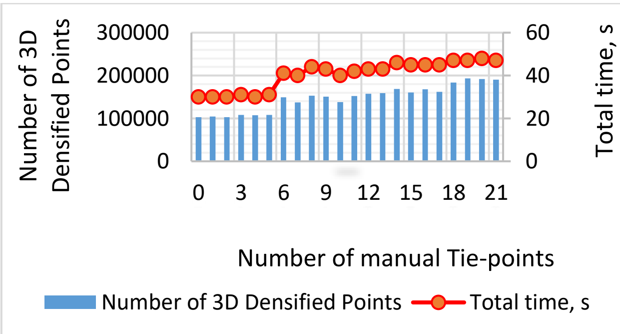
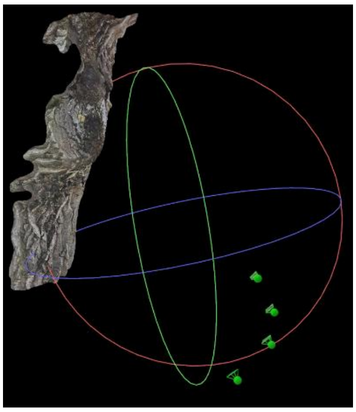


Fig 6 Dependence between Number of 3D Densified Points, Total time and Number of manual Tie-points

Table 1 Results of indicators in the course of adding manual tie-points

Manual Tie-Points			Number of 3D Points observed ***					Time for (s):			
Manual Tie-point number (used Manual Tie-points)	Verified/Marked *	Camera optimization (%) **	In 2 Images	In 3 Images	In 4 Images	Number of 3D Densified Points	Cameras and the final partial 3D model	Initial processing	Point Cloud densification	3D textured mesh generation	Total time
0	-	*4,71*	*12279*	*325*	*12*	*103216*		*9*	*9*	*12*	*30*
1	3/3	4,58	12268	334	14	104439		9	9	12	30
2	4/4	4,69	12271	326	10	103250		9	9	12	30
3	4/4	2,27	12267	349	16	108331		9	10	12	31
4	2/2	2,28	12267	349	16	107684		9	9	12	30
5	4/4	2,12	12262	358	15	108247		9	10	12	31
6	4/4	30,66	12167	447	19	149578		17	11	13	41
7	4/4	25,56	12205	418	17	137070		16	11	13	40
8	3/4	33,83	12171	447	19	152894		19	12	13	44
9	4/4	34,01	12171	447	19	150571		18	12	13	43
10	4/4	27,7	12180	439	17	138198		16	11	13	40
11	4/4	34,54	12178	441	18	151932		18	11	13	42
12	4/4	37,23	12164	450	21	157146		18	12	13	43
13	4/4	37,08	12167	447	21	158983		18	12	13	43
14	4/4	41,55	12155	457	24	168392		19	13	14	46
15	4/4	38,49	12168	448	21	160691		20	12	13	45
16	4/4	41,89	12154	457	23	167645		20	12	13	45
17	4/4	38,68	12164	453	25	162049		20	12	13	45
18	4/4	46,69	12145	468	26	183569		20	13	14	47
19	4/4	50,43	12135	467	28	193190		19	14	14	47
20	4/4	49,24	12129	468	27	192119		20	14	14	48
21	4/4	49.13	12126	466	28	190327		20	13	14	47

* Number of images where the manual tie point has been automatically verified vs. manually marked. [13]
** Relative difference between initial and optimized internal camera parameters. [13]
*** 3D Points from 2D Keypoint Matches. [13]

Of course, the processing time also increases with the number of added manual Tie-Points. From the total number of 21 manual Tie-points, we will show the real results of forming a partial model. We present these results in figure 7.

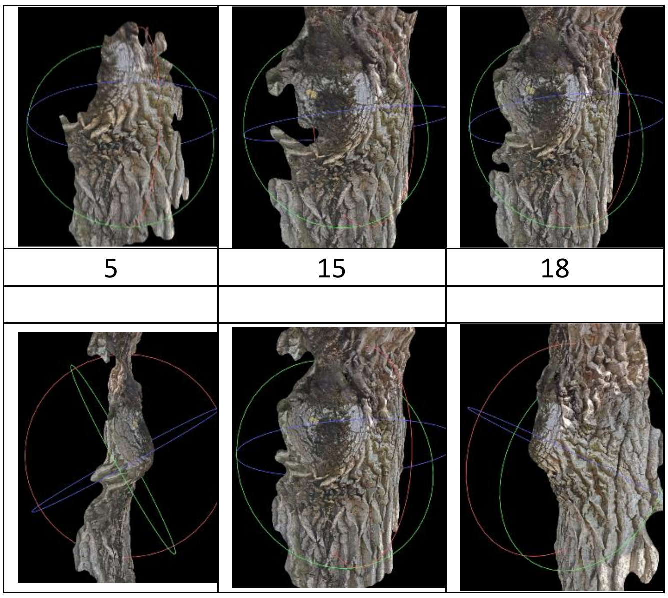


Fig 7 Above: 3D model of the desired area using 5, 15 and 18 manual Tie-points. Bottom: Final partial 3D model from three views. Available at: https://skfb.ly/oGKHI

IV. CONCLUSION

In conclusion, we can state that by adding manual Tie-Points we managed to obtain the required area of the 3D model. These procedures are equally well applicable both in technical practice and in the educational process, when they can also bring good results.

REFERENCES

[1] Á. Sándor and Á. Gubán, *A Measuring Tool for the Digital Maturity of Small and Medium-Sized Enterprises*, Management and Production Engineering Review, 2021, vol. 12: 4 pp. 133-143. , 11 p.

[2] Á. Sándor and Á. Gubán, *A multi-dimensional model to the digital maturity life-cycle for SMEs*, International Journal of Information Systems and Project Management, 2022, vol. 10: 3 pp. 58-81. , 24 p.

[3] Á. Gubán and Z. Mezei, *Modeling Economic Processes of Hungarian Prison Service*, Asian Business Research, 2017, vol. 2: 1 pp. 31-41. , 11 p.

[4] I. Roll and R. Wylie, *Evolution and Revolution in Artificial Intelligence in Education*, Int J Artif Intell Educ, 2016, vol. 26, 582–599. https://doi.org/10.1007/s40593-016-0110-3

[5] F. Liu and P. Kromer, "Early Age Education on Artificial Intelligence: Methods and Tools," in *Kovalev, S., Tarassov, V., Snasel, V., Sukhanov, A. (eds) Proceedings of the Fourth International Scientific Conference "Intelligent Information Technologies for Industry" (IITI'19). IITI 2019*, Advances in Intelligent Systems and Computing, 2019, vol. 1156. https://doi.org/10.1007/978-3-030-50097-9_71

[6] J. Udvaros and L. Végh, "Possibilities of Creating Interactive 2D Animations for Education Using HTML5 Canvas JavaScript Libraries," *in Proceedings of the 16th International Scientific Conference "eLearning and Software for Education", Bucharest: Editura Universitara*, pp. 269–274, Apr. 2020, doi: 10.12753/2066-026X-20-119.

[7] K. Czakóová "Mathematical Model Based Interactive Simulations in Education," in *ICERI 2019 Proceedings of the 12th International Conference of Education, Research and Innovation: Enlightening Minds through Education, Seville: IATED Academy*, p. 10120-10125, 2019. DOI: 10.21125/iceri.2019.2479, ISBN 978-84-09-14755-7. ISSN 2340-1095.

[8] D. Paksi, M. Csóka and Sz. Svitek, "Spreadsheets Feasibility for Modeling in Education", *14th International Conference on Education and New Learning Technologies*, pp. 5855-5861, 2022. doi: 10.21125/edulearn.2022.1371

[9] Ch. Pellant, *Rocks and Minerals*, Dorling Kindersley Plc P/B, 2000, p. 256. ISBN: 9780751327410

[10] J. Udvaros, N. Forman, L. Szabó and K. Szabó, "The Importance of Teaching Drones in Logistics," *ICERI2022 Proceedings*, pp. 3286-3290, 2022. doi: 10.21125/iceri.2022.0811

[11] L. Radácsi, M. Gubán, L. Szabó and J. Udvaros, *A Path Planning Model for Stock Inventory Using a Drone*. Mathematics, 2022, vol. 10(16):2899. https://doi.org/10.3390/math10162899

[12] M. Gubán and J. Udvaros, *A Path Planning Model with a Genetic Algorithm for Stock Inventory Using a Swarm of Drones*, Drones, 2022, vol. 6(11):364. https://doi.org/10.3390/drones6110364

[13] Pix4D, pix4D User manual, pix4D documentation, https://support.pix4d.com/hc/en-us/sections/360003718992-Manual

[14] CZAKÓOVÁ, K.: Developing algorithmic thinking by educational computer games. In. Proceedings of the 16th International Scientific Conference: "eLearning and Software for Education : eLearning sustainment for never-ending learning. Volume 1, DOI: 10.12753/2066-026X-20-003, 2020/1, p. 26-33. Bucharest : "CAROL I" National Defence University Editura, Universitara, 2020. ISSN 2066-026X, ISSN-L 2066-026X, ISSN CD 2343 – 7669. Scopus

[15] CZAKÓOVÁ, K. – STOFFOVÁ, V.: Training teachers of computer science for teaching algorithmization and programming. In: IMSCI´20 : proceedings, The 14th International Multi-conference on Society, Cybernetics and Informatics : Proceedings (Post-Conference Edition). Winter Garden: International Institute of Informatics and Systemics, 2020, p. 231-235. ISBN 978-1-950492-40-4. SCOPUS

[16] CZAKÓOVÁ, K. – TAKÁČ, O.: The application of modern technologies for image processing and creating

real model in teaching computer science at secondary school. In. ICERI 2020 Proceedings of the 13th International Conference of Education, Research and Innovation. DOI: 10.21125/iceri.2020.1330, p. 6180-6187, Seville : IATED Academy, 2020. ISBN 978-84-09-24232-0. ISSN 2340-1095.

[17] CZAKÓOVÁ, K.: Game-based programming in primary school informatics. In. INTED 2021 : Proceedings of the 15th International Technology, Education and Development Conference. DOI: 10.21125/inted.2021.1134 , p. 5627-5632, Valencia : IATED Academy, 2021. ISBN 978-84-09-27666-0. ISSN 2340-1079.

[18] CSÓKA, M. – CZAKÓOVÁ, K.: Innovations in education through the application of raspberry pi devices and modern teaching strategies. In. INTED 2021 : Proceedings of the 15th International Technology, Education and Development Conference. DOI: 10.21125/inted.2021.1327, p. 6653-6658, Valencia : IATED Academy, 2021. ISBN 978-84-09-27666-0. ISSN 2340-1079.

[19] CZAKÓOVÁ, K. - UDVAROS, J.: Applications and games for the development of algorithmic thinking in favor of experiential learning. In. EDULEARN21 : Proceedings of the 13th International Conference on Education and New Learning Technologies. DOI: 10.21125/edulearn.2021.1389, p. 6873-6879, Valencia : IATED Academy, 2021. ISBN 978-84-09-31267-2. ISSN 2340-1117.

[20] J. Udvaros, N. Forman, L. Szabó, K. Szabó (2022) THE IMPORTANCE OF TEACHING DRONES IN LOGISTICS, ICERI2022 Proceedings, pp. 3286-3290. doi: 10.21125/iceri.2022.0811

[21] J. Udvaros and K. Czakóová. (2021) Using teaching methods based on visualizing by TinkerCad in teaching programming, ICERI2021 Proceedings, pp. 5913-5917. https://doi.org/10.21125/iceri.2021.1333

[22] J. Udvaros and K. Czakóová. (2021) Developing of computational thinking using microcontrollers and simulations, EDULEARN21 Proceedings, pp. 7945-7951. https://doi.org/10.21125/edulearn.2021.1619

[23] M. T. Fülöp, J. Udvaros, Á. Gubán, and Á. Sándor. (2022) Development of Computational Thinking Using Microcontrollers Integrated into OOP (Object-Oriented Programming). Sustainability, 14 12, 7218, https://doi.org/10.3390/su14127218

[24] GUBO, Štefan – VÉGH, Ladislav – JUHÁSZ, György: Úspešnosť žiakov stredných škôl na Slovensku i v Maďarsku v riešení úloh z informatiky testu STEM – Výsledky pilotného prieskumu. In: Roman Hašek (ed.): Sborník příspěvků 10. konference Užití počítačů ve výuce matematiky. Jihočeská univerzita v Českých Budějovicích, 2021. pp. 44–55. ISBN 978-80-7394-906-8.

[25] GUBO, Štefan – VÉGH, Ladislav: Az informatikai, a logikus és az algoritmikus gondolkodás felmérése középiskolás tanulók és egyetemi hallgatók körében. In: Juhász, György – Tóth, Péter (eds.): A természettudományos és matematikai tárgyak tanításának és tanulásának helyzete Magyarországon és Szlovákiában. Lektorálta: Prof. Benedek András, DSc.; Dr. habil. Simonics István. Komárno : Univerzita J. Selyeho, 2021. pp. 228–290. ISBN 978-80-8122-405-8.

[26] VÉGH, Ladislav – GUBO, Štefan: Assessment of Algorithmic and Logical Thinking of First- and Second-Year Computer Science Students at J. Selye University in Academic Years 2019/20 and 2021/22. In: Luis Gómez Chova – Agustín López Martínez – Joanna Lees (eds.): ICERI2022 Proceedings. 15th International Conference of Education, Research and Innovation. 7-9 November, 2022. pp. 1888– 1895. ISBN 978-84-09-45476-1, ISSN 2340-1095. DOI: https://dx.doi.org/10.21125/iceri.2022.0480.

[27] GUBO, Štefan – VÉGH, Ladislav: Assessment of Algorithmic Thinking of Slovak and Hungarian Secondary School Students. In: Luis Gómez Chova – Agustín López Martínez – Joanna Lees (eds.): ICERI2022 Proceedings. 15th International Conference of Education, Research and Innovation. 7-9 November, 2022. pp. 3484– 3493. ISBN 978-84-09-45476-1, ISSN 2340-1095. DOI: https://dx.doi.org/10.21125/iceri.2022.0849.