Using and Citation of 3D Modeling Software for 3D Printers

Radek Nemec

***Abstract*—**This article describes the use of 3D modeling software for 3D printers in scientific journals. The citation survey was carried out on 20 selected types of 3D modeling software in the Scholar search engine. The survey has been conducted over the last 5 years. The article, using clear graphs and tables, provides information on the amount of quotations of these selected types of 3D modeling software include the destricption of all of them software. This overview is intended to help choose 3D Modeling Software for 3D Printing.

***Keywords*—**3D printers, 3D modeling software, 3D modeling software for 3D printers, model, using, citation.

I. Introduction

In recent years, there has been a huge expansion in 3D printers. This is due to the gradually decreasing price of these printers. [1, 2, 3, 4] A large impact of this decline is the RepRap project [5, 6, 7]. RepRap is an open-source community project. Everyone can build their own RepRap, improve it and revive its improvements back to the community. RepRap is a free desktop 3D printer able of printing 3D plastic objects. And since RepRap is composed of many such plastic parts, it can be considered a self-replicating machine. This means that if you have RepRap, you can print a lot of useful things, including parts for building another RepRap.

II. 3D Modeling Software for 3D Printers

Create a 3D model is required for printing on a 3D printer. 3D modeling software has existed for a long time. From professionals such as AutoCAD, SolidWorks, Inventor, 3DS MAX, Blender to simple use and as freeware. For example, the recently popular TinkerCAD or more technical OnShape or FreeCAD. Without 3D modeling software, no modeling is possible. In past times, everything was made by hand. At the time of computers, it is fortunately to make 3D models very easy. And thanks to 3D printers, the actual model is created instantly.

Finding software to avoid everyone is not easy. Everyone has different demands. This is can be stressed [8, 9, 10]. One wants the simplest for very fast modeling. This is good for beginners or for modeling in schools. Others want professional software, where is able to model the entire gearbox or even the whole car. Others want to model using the programming language. Where to define code parameters and modeling software creates the resulting model. Another one wants to combine modeling with programming. Someone moves to model 3D objects from a sketch in two dimensions, with the subsequent sliding of the surface. Differences are also economic. At work, a person has access to paid versions. At home, a person has to settle for freely available applications. Students also have the opportunity to use professional paid software in the student license. This is very convenient. Sometimes, however, with restrictions. [11, 12, 13, 14, 15, 16, 17] See Fig. 1, 2 and 3.

Fig. 1 3D Modeling Software for 3D Printers [18]

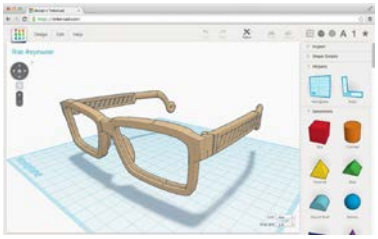

Fig. 2 3D Modeling Software for 3D Printers [19]

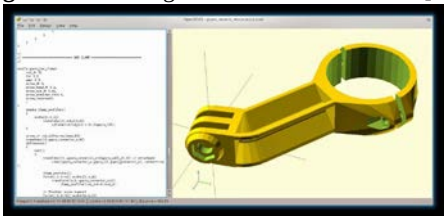

Fig. 3 3D Modeling Software for 3D Printers [19]

The paper has been supported by Specific Research Project of Faculty of Science, University of Hradec Kralove, No. 2102, 2017.

Radek Nemec is with the University of Hradec Kralove, Faculty of Science, Rokitanskeho 62, Hradec Kralove, 500 03, Czech Republic, (phone: +420 774 220 193; e-mail: radek.nemec@uhk.cz).

III. Using and Citation of 3D Modeling Software for 3D Printers

This article focuses on the citation of the most popular 3D modeling software for 3D printers.

The reason for listing the most popular 3D modeling software for 3D printers was the reason to find out how this software are used in the scientific sphere.

A. Research Methodology

The selection of the most popular 3D software for 3D printers has been taken from the article Top 20 article: Most Popular 3D Modeling & Design Software for 3D Printing (2017 Update) [20]. This article was chosen because of a very well-developed selection methodology. In addition to this overview, there are other very sophisticated reports. Very good selections are in this article Software For 3D Printing [19] or in 20 Best 3D Printing Software Tools (All Are Free) [21] and in Software & Tools [22].

The methodology of producing citations listing of this most popular 3D modeling software for 3D printers is as follows. The report has always selected specific software and a freely accessible Google search engine that indexes full texts or metadata from professional literature. Google Scholar [23] was searched for the software. This has revealed the number of citations. 3D modeling software for 3D printers is mainly used in the last few years. Because of this, the last five years have been selected for the citation report. Since it was not yet 2017, this year was released from the survey. The range of citation is therefore between 2012 and 2016.

B. The Results of Top 20: Most Popular 3D Modeling & Design Software for 3D Printing (2017 Update)

The following table (Table I) lists the 20 most popular 3D modeling software for 3D printers according to the methodology from the article Top 20: Most Popular 3D Modeling & Design Software for 3D Printing (2017 Update) [20].

The methodology is following.

„General popularity:

- Social Media Score: The first factor that we took into account is the overall popularity of the software on social networks. This includes the number of fans, followers, and mentions on social media.
- Website Score: This is a score developed by Moz that predicts how well a specific page ranks on search engines and includes various sub-variables (for example link counts).

While these two factors show the overall popularity of the software, they do not distinguish between using the software for 3D printing or for any other purpose. That is why we added some more factors that are related to 3D printing:

Popularity in the 3D printing community:

- 3D Printing Forum Mentions: We calculated how often the software is mentioned in leading 3D printing forums (e.g. 3dprintboard.com or 3D Hubs Talk).
- 3D Printing Video Mentions: This number shows how often the software is tagged in 3D printing videos on YouTube. It includes mentions such as “3D printing with XY”, “XY tutorial for 3D printing”, etc.
- 3D Models in 3D Printing Databases: This is a score that shows how often 3D models in 3D printing databases and communities were tagged with a specific software. A higher score means that many 3D printable models were tagged with the name of this software.
- 3D Printing Google Score: This number shows how often the software is mentioned in the context of 3D printing on Google.” [20] See Table I.

Table I. Most Popular 3D Modeling Software for 3D Printing [20]

Most Popular 3D Modeling Software for 3D Printing

Rank	Software	General		3D Printing Community				Total Score
		Social	Website	Forum	YouTube	Models	Google	
1	Blender	67	89	97	100	57	92	**83,7**
2	SketchUp	93	82	100	96	52	76	**83,2**
3	SolidWorks	99	77	92	97	46	76	**81,2**
4	Fusion 360	96	85	53	95	15	99	**73,8**
5	Inventor	95	81	61	70	11	100	**69,7**
6	Maya	93	85	15	94	3	100	**65,0**
7	AutoCAD	100	84	27	93	7	73	**64,0**
8	3DS Max	97	84	47	91	4	60	**63,8**
9	ZBrush	87	67	39	90	5	66	**59,0**
10	TinkerCAD	91	74	48	21	100	19	**58,8**
11	Cinema4D	89	73	44	9	7	64	**47,7**
12	Rhinoceros	32	72	52	39	12	66	**45,5**
13	OpenSCAD	2	66	51	3	95	54	**45,2**
14	MODO	85	48	10	10	1	37	**31,8**
15	Meshmixer	4	58	41	13	23	5	**24,0**
16	Sculptris	44	65	10	3	6	4	**22,0**
17	PTC Creo Parametric	36	65	6	7	3	14	**21,8**
18	FreeCAD	10	61	13	11	29	2	**21,0**
19	Solid Edge	47	45	4	2	1	26	**20,8**
20	OnShape	36	59	3	3	12	3	**19,3**

i.materialise

C. The Results of Citation

Table 2 shows citation counts between 2012 and 2016. For software Rhinoceros and MODO, the number of citations could not be adequately determined due to a large confusion about another topic. In the case where another topic was predominant, it was manually checked whether the topic was included among 3D modeling software for 3D printers. See Table II.

Table II. Citation of 3D Modeling Software for 3D Printing

software/year	2012	2013	2014	2015	2016
Blender	16000	17700	18700	19100	19000
SketchUp	2340	3010	2710	3150	2790
SolidWorks	11400	13300	13600	14500	14900
Fusion360	-	1	28	52	118
Inventor	34000	32900	31300	29400	27400
Autodesk Maya	519	681	703	730	685
AutoCAD	12900	13900	13600	12700	13100
3DSMax	2250	2480	2340	2490	2050
Zbrush	196	237	258	339	337
Tinkercad	16	55	93	164	187
Cinema4D	78	88	110	97	93
Rhinoceros	-	-	-	-	-
OpenSCAD	47	59	111	183	200
MODO	-	-	-	-	-
Meshmixer	11	24	45	122	213
Sculptris	22	26	31	60	41
PTC Creo Parametric	3	23	35	74	91
FreeCAD	38	64	110	184	183
Solid Edge	964	785	952	857	802
OnShape	1	1	4	17	48

For clarity, the following table shows the sum of all citations in years 2012-2016. See Table III.

Table III. Citation of 3D Modeling Software for 3D Printing 2012 - 2016

Software/Year	2012 - 2016
Blender	90 500
SketchUp	14 000
SolidWorks	67 700
Fusion 360	199
Inventor	155 000
Autodesk Maya	3 318
AutoCAD	66 200
3DS Max	11 610
Zbrush	1 367
Tinkercad	515
Cinema4D	466
Rhinoceros	-
OpenSCAD	600
MODO	-
Meshmixer	415
Sculptris	180
PTC Creo Parametric	226
FreeCAD	579
Solid Edge	4 360
OnShape	71

The following figures show graphically the number of citations. See Fig 4.

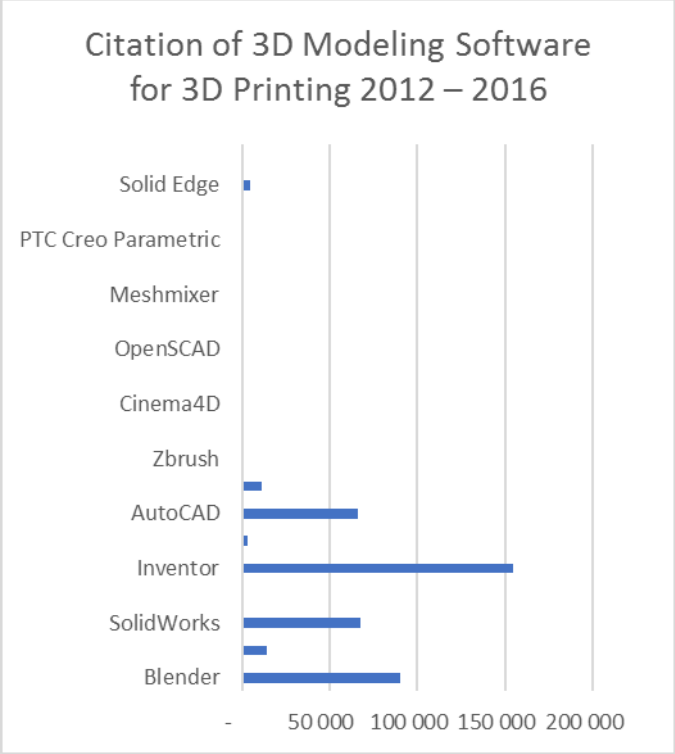

Fig. 4 Citation of 3D Modeling Software for 3D Printing 2012 – 2016

The number of citations is not visible in the graph. This is due to many citations of professional modeling software. Therefore, this software has been excluded from the chart. Excluded software are AutoCAD, Inventor, SolidWorks, and Blender. The following figure shows a better view of the number of citations. See Fig. 5

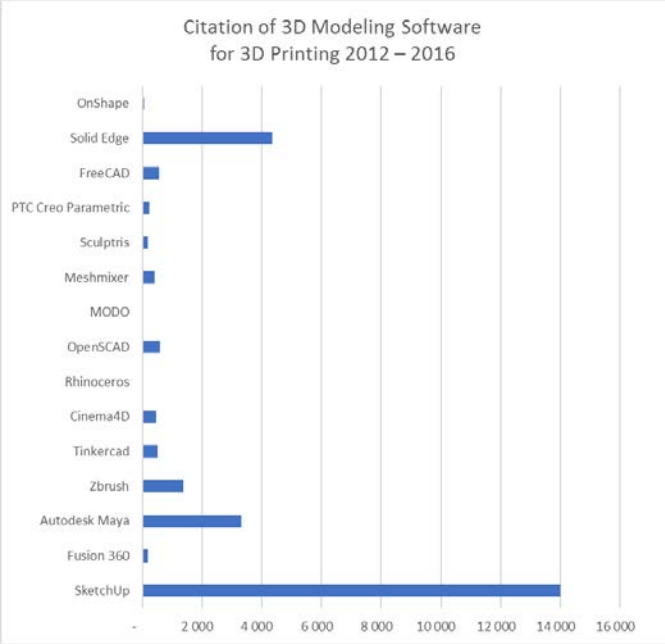

Fig. 5 Citation of 3D Modeling Software for 3D Printing 2012 – 2016

Even though professional software has been developed, the chart is not so clear. That's why it was outcast, though popular, SketchUp and FreeCad. The following figure shows the number of citations of 3D Modeling Software for 3D Printing software. Alternate software remained in the chart. See Fig. 6.

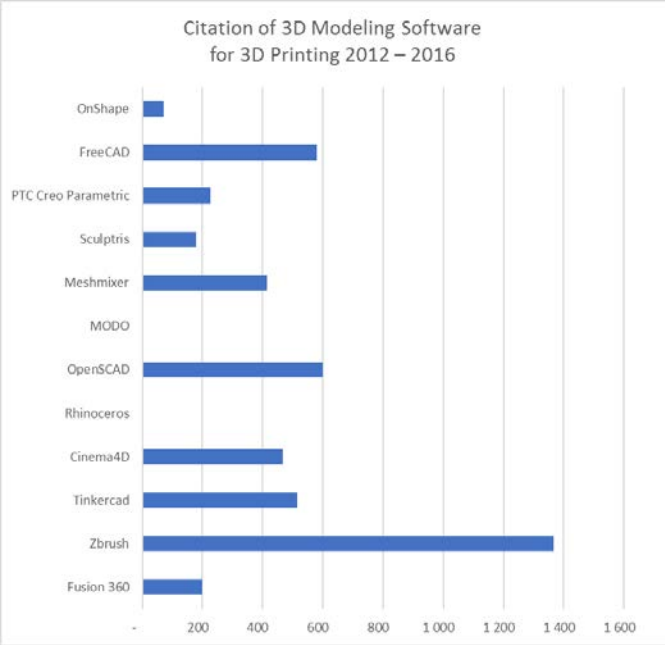

Fig. 6 Citation of 3D Modeling Software for 3D Printing 2012 – 2016

For completeness of the citation overview, a citation table is also provided in the January to the end of October 2017. That is until the creation of this article. See Table IV.

Table IV. Citation of 3D Modeling Software for 3D Printing 2017

Software/Year	2017
Blender	12 100
SketchUp	1 780
SolidWorks	7 500
Fusion 360	156
Inventor	24 700
Autodesk Maya	432
AutoCAD	6 150
3DS Max	1 140
Zbrush	234
Tinkercad	184
Cinema4D	44
Rhinoceros	-
OpenSCAD	186
MODO	-
Meshmixer	242
Sculptris	38
PTC Creo Parametric	62
FreeCAD	205
Solid Edge	570
OnShape	55

IV. Top 20 3D Modeling Software for 3D Printing

This section describes 20 most popular 3D Modeling Software for 3D Printing.

A. Blender

Blender is the free and open source 3D creation software. This software supports the entirety of the 3D pipeline—modeling, rigging, animation, simulation, rendering, compositing and motion tracking, even video editing and game creation. Users employ Blender's API for Python scripting to customize the application and write specialized tools; often these are included in Blender's future releases. The Blender is well suited to individuals and small studios who benefit from its unified pipeline and responsive development process. For examples from many Blender-based projects are available in the showcase.

Blender is cross-platform and runs on Linux, Windows, and Mac OS X systems on computers. Its interface uses OpenGL to provide a consistent experience, to confirm specific compatibility, the list of supported platforms indicates those

regularly tested by the development team.

As a community-driven project under the GNU General Public License (GPL), the public is empowered to make small and large changes to the code base, which leads to new features, responsive bug fixes, and better usability, blender has no price tag, but you can invest, participate, and help to advance a powerful collaborative tool: Blender is your 3D software. [24]

Fig. 7 Blender [25]

B. SketchUp

SketchUp is 3D modeling software. That's easy to learn and incredibly fun to use. SketchUp users are architects, designers, builders, makers and engineers; they are the people who shape the physical world, they are important, and they deserve great tools because great tools produce great work.

Great tools are ones you look forward to using, they do one thing (or maybe two) really, really well, and they let you do what you want without having to figure out how., help with hard or boring tasks so that you can focus on being creative, or productive, or both and they are, in their own way, beautiful.

SketchUp have best to make great tools for drawing. For users, drawing is thinking, they draw to explore ideas, to figure things out, to show other people what they mean and draw because they love it, and because nothing great was ever built that didn't start with a great drawing. [26]

Fig. 8 SketchUp [27]

C. SolidWorks

SolidWorks as a parametric 3D modeler offers powerful volume and surface modeling, vertical tooling for metal parts, weldments and molds, working with unlimited large assemblies, and automatic generation of production drawings. The SolidWorks user interface is very intuitive and delivers quick workflows, reduces mouse movements quickly and enables instant, context-sensitive interaction with the user, the control is based on SWIFT technology, which reduces the need for repetitive operations, manual interventions and operations where neither an experienced user is ahead of course and often goes through the error attempt method. SWIFT can save a considerable amount of time and allow to devote more attention to the process of designing, not controlling the system itself. [28]

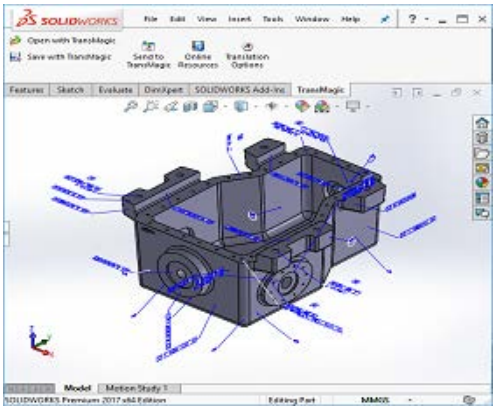

Fig. 9 SolidWorks [29]

D. Fusion 360

Fusion 360 is the first 3D CAD, CAM, and CAE tool of its kind, it connects your entire product development process in a single cloud-based platform that works on Mac OS x and PC. It is Cloud-based 3D CAD/CAM/CAE software for simulation and design from AutoDesk. Design - Quickly iterate on design ideas with sculpting tools to explore form and modeling tools to create finishing features. Engineer and Simulation - Test fit and motion, perform simulations, create assemblies, make photorealistic renderings and animations, CAM - Create toolpaths to machine your components or use the 3D printing workflow to create a prototype. [30]

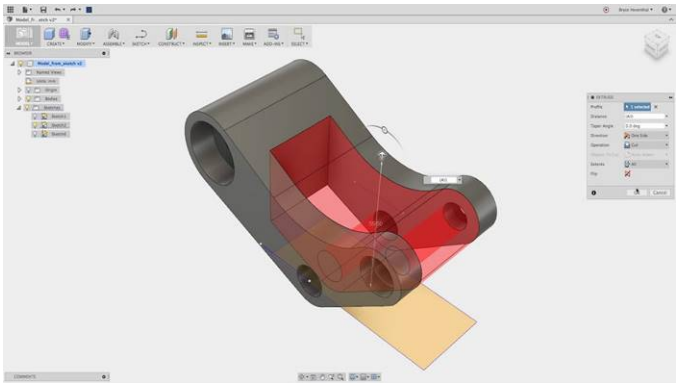

Fig. 10 Fusion 360 [31]

E. Inventor

Inventor is also from AutoDesk. 3D CAD software Autodesk Inventor is used for product design, visualization and simulation, Inventor is a parametric, adaptive 3D modeller. Inventor includes features for adaptive and parametric 3D designing, 2D drawing documentation, presentation and photorealistic visualization and animation, and document management and design data. The design basis for Inventor consists of parts (IPT) whose geometry can be derived from parametric 2D sketches, these components can then be combined and bound by different assembly types (IAM). When changing a dimension, parameter, or geometry, the entire 3D assembly, including its drawing documentation (views, cuts, details, BOMs), is automatically re-generated and updated. Besides standard tools for volume and surface 3D modeling, Inventor also includes functions for modeling sheet metal parts, weldments, steel structures. [32]

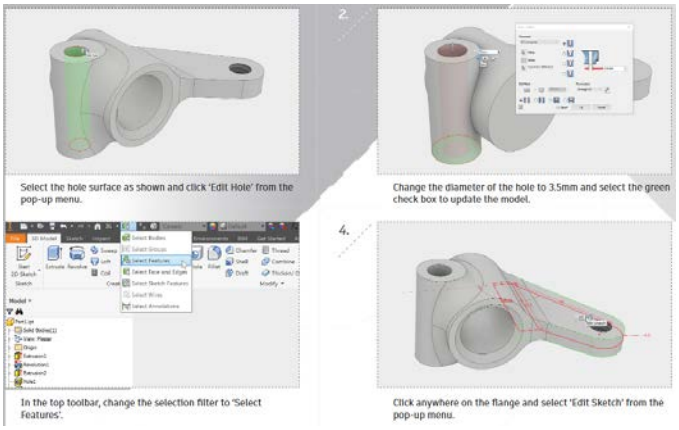

Fig. 11 Inventor [33]

F. Autodesk Maya

Autodesk Maya is 3D computer animation software with powerful modeling, rendering, simulation, texturing, and animation tools for artists, modelers, and animators. Software provides an integrated, powerful toolset, it is use for animation, environments, motion graphics, virtual reality, and character creation. It is use to generate 3D assets for use in film, television, game development and architecture. [34]

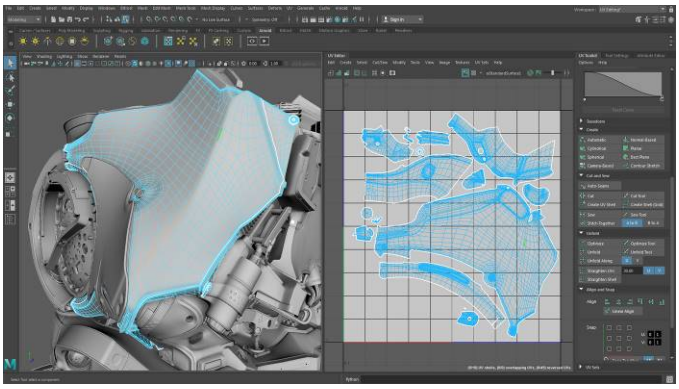

Fig. 11 Autodesk Maya [35]

G. AutoCAD

AutoCAD is a popular software for 2D and 3D design and construction (CAD) developed by Autodesk and it has developed a suite of CAD applications for engineering, building design and architecture, mapping, and landscaping. [36]

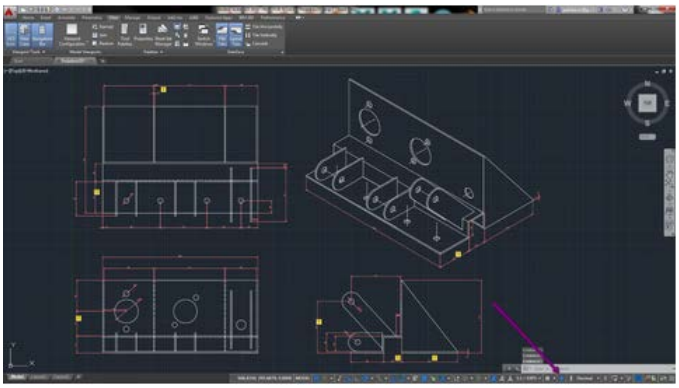

Fig. 11 AutoCAD [37]

H. 3DS Max

3ds Max is software for 3D modeling, animation, rendering, and visualization, create stunning scenes, detailed characters and bring realistic scenes to life. 3ds Max 3D modeling and rendering software helps to create massive worlds in games, stunning scenes for design visualization, and engaging virtual reality (VR) experiences. 3ds Max software provides a comprehensive 3D modeling, animation, rendering, and compositing solution for games, film, and motion graphics artists and 3ds Max has tools for crowd generation, particle animation, and perspective matching, as well as support for DirectX 11 shaders. [38]

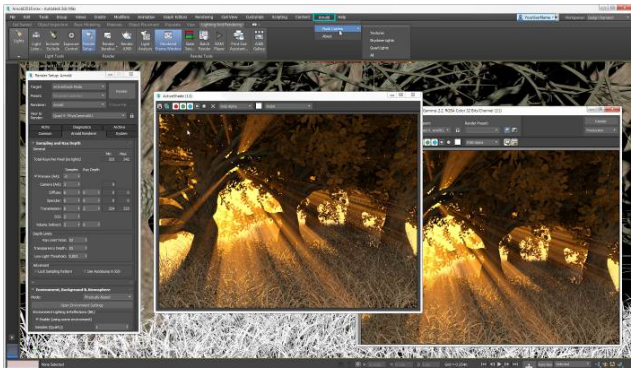

Fig. 12 A. 3DS Max [39]

I. Zbrush

Zbrush is a professional graphics editor for 3D and 2.5D modeling, texturing and painting. ZBrush is a digital sculpting and painting program that has revolutionized the 3D industry with its powerful features and intuitive workflows. ZBrush it is built within an elegant interface, offers the world's most advanced tools for today's digital artists. With an arsenal of features that have been developed with usability in mind, creates a user experience that feels incredibly natural while simultaneously inspiring the artist within. With the ability to sculpt up to a billion polygons, allows you to create limited only by your imagination. [40]

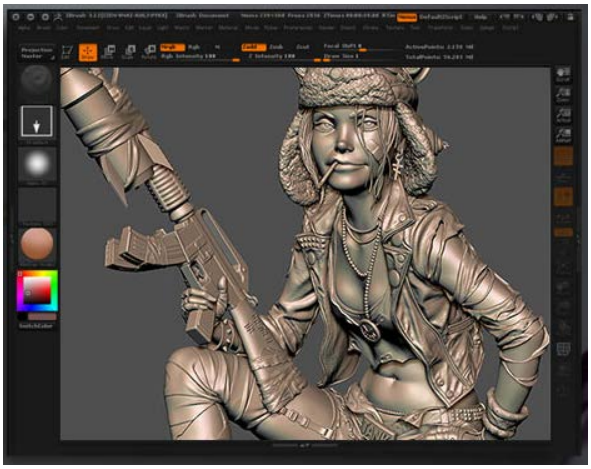

Fig. 13 AutoCAD [40]

J. Tinkercad

Autodesk also made Tinkercad. Tinkercad is a simple tool for 3D design and modeling based on a browser for everyone. You can imagine anything and suggest it in Tinkercad within minutes. It is used by designers, hobbyists, teachers, and kids, to make toys, prototypes, home decor, Minecraft models, jewelry – the list is truly endless! "Shapes are the basic building blocks of Tinkercad. Any shape can add or remove material, and you can also import or create your own shapes. By grouping together a set of shapes you can create new models to work with. Build intricate shapes and create extremely detailed models. Create vector shapes, then import and extrude them into 3D models. Additionally, you can import external 3D files which become editable Tinkercad shapes." [41]

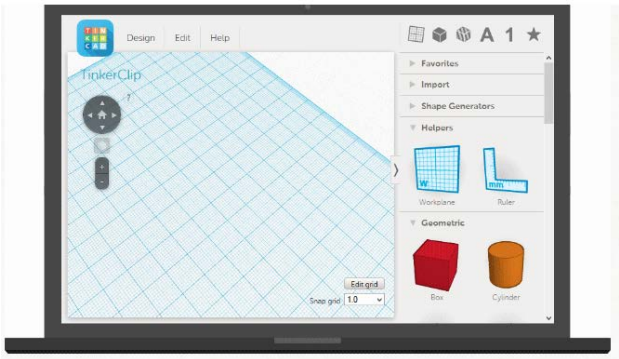

Fig. 13 Tinkercad [42]

K. Cinema4D

Cinema 4D is the package for all 3D artists who want to achieve breathtaking results fast and hassle-free. It is easy to learn and extremely powerful: Cinema 4D is the perfect package for all 3D artists who want to achieve breathtaking results fast and hassle-free, beginners and seasoned professionals alike can take advantage of Cinema 4D's wide range of tools and features to quickly achieve stunning results. Software Cinema 4D's legendary reliability also makes it the perfect application for demanding, fast-paced 3D production, and a range of attractively priced software packages is available to fit any artist's needs. [43]

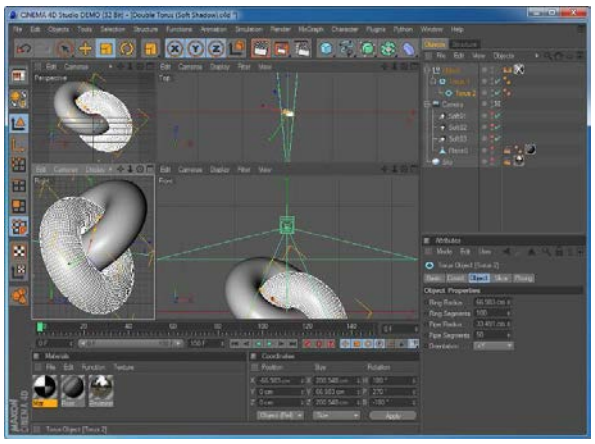

Fig. 14 Cinema 4D [44]

L. Rhinoceros

Rhinoceros 3D is a modeling software for spatial objects. It is mainly used in design and architecture. Rhino can create, edit, analyze, document, render, animate, and translate

NURBS* curves, surfaces, and solids, point clouds, and polygon meshes, there are no limits on complexity, degree, or size beyond those of your hardware. [45]

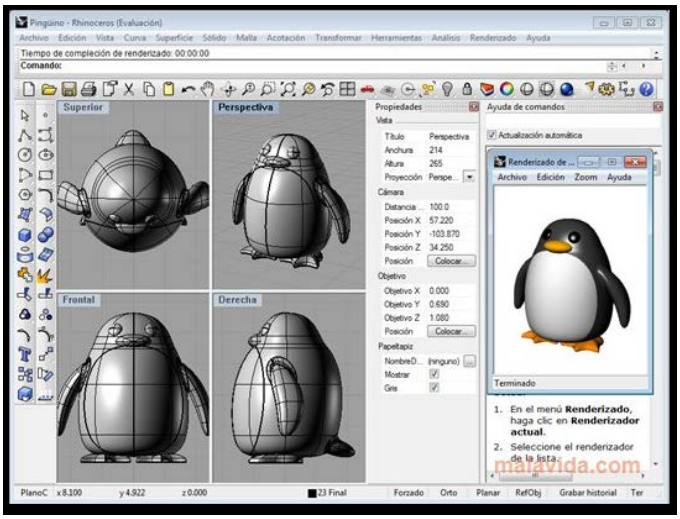

Fig. 15 Rhinoceros [46]

M. OpenSCAD

OpenSCAD is software for creating solid 3D CAD objects and it is free software and available for all platforms like as Linux/UNIX, MS Windows and Mac OS X. Unlike most free software for creating 3D models (such as Blender) it does not focus on the artistic aspects of 3D modelling but instead on the CAD aspects, thus it might be the application you are looking for when you are planning to create 3D models of machine parts but pretty sure is not what you are looking for when you are more interested in creating computer-animated movies. OpenSCAD is not an interactive modeller. Instead it is something like a 3D-compiler that reads in a script file that describes the object and renders the 3D model from this script file, this gives you (the designer) full control over the modelling process and enables you to easily change any step in the modelling process or make designs that are defined by configurable parameters. [47]

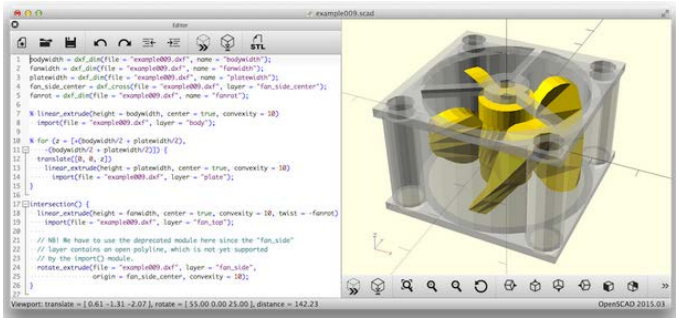

Fig. 16 Cinema 4D [48]

N. MODO

Modo is powerful and flexible 3D modeling, texturing and rendering toolset. It is empowers artists to explore and develop ideas without jumping through technical hoops. Modo is starting point for creative exploration. [49]

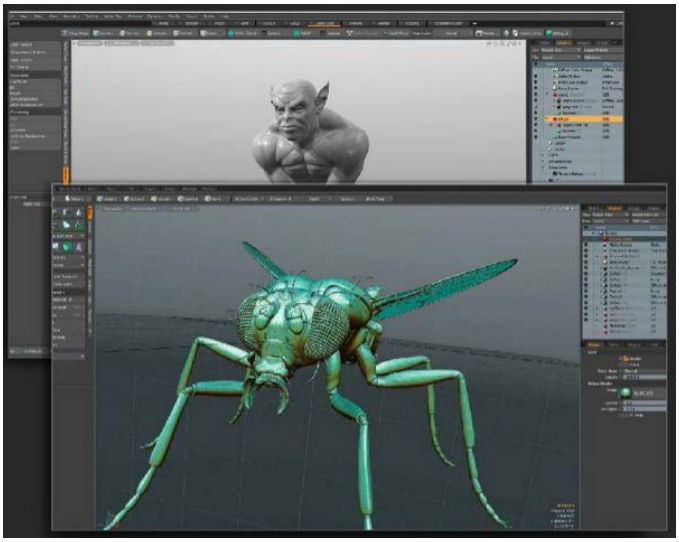

Fig. 17 MODO [49]

O. Meshmixer

Meshmixer is state-of-the-art software for working with triangle meshes. It is free software for making awesome stuff. Meshmixer is a prototype design tool based on high-resolution dynamic triangle meshes. This software is from Autodesk too. [50]

Fig. 17 Meshmixer [51]

P. Sculptris

Sculptris is an excellent gateway into the exciting world of 3D. It is features are easy to learn, even for beginner, for someone with no experience in digital art, yet robust enough for creating base models that can then be refined in other applications, such as ZBrush. [52]

Fig. 18 Sculptris [52]

Q. *PTC Creo Parametric*

Creo Parametric is the core modeling strengths you would expect from the industry leader, along with breakthrough capabilities in additive manufacturing, model based definition (MBD) and smart connected design, streamlined workflows and an intuitive user interface complete the picture. [53]

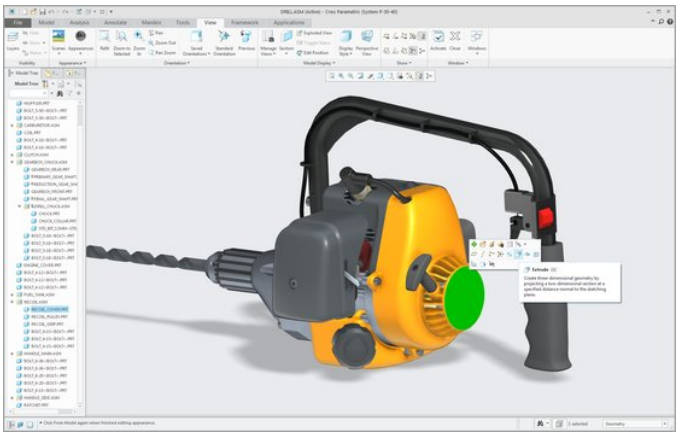

Fig. 19 PTC Creo Parametric [53]

R. *FreeCAD*

FreeCAD is a parametric 3D modeler made primarily to design real-life objects of any size, parametric modeling allows you to easily modify your design by going back into your model history and changing its parameters. This software is open-source and highly customizable, scriptable and extensible. [54]

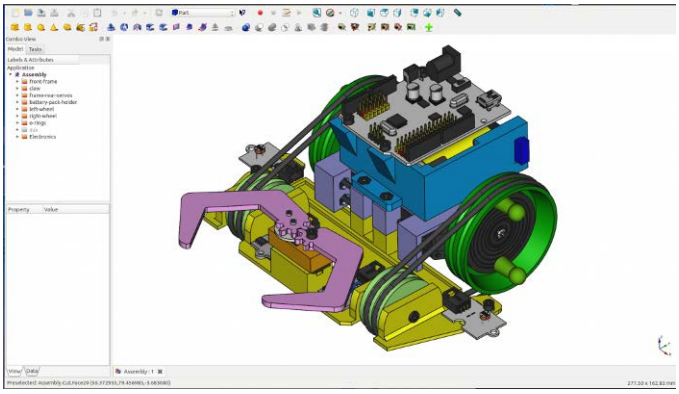

Fig. 20 FreeCAD [55]

S. *Solid Edge*

Solid Edge is an industry-leading mechanical design system. Solid Edge is with exceptional tools for creating and managigng 2D and 3D digital prototypes. Modeling and asssembly tools enable to develop a full range of products, froma a single part to an assembly containing thousands of components. [56]

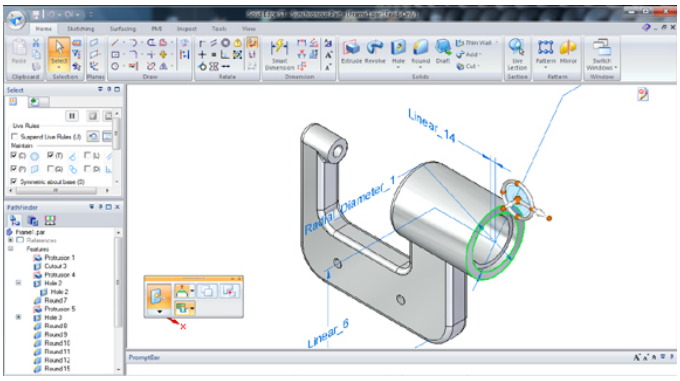

Fig. 21 Solid Edge [57]

T. *OnShape*

OnShape is can design, version, and share parts, assemblies, and drawings from anywhere for less than your legacy CAD maintenance fees. It is from creators of Solid Works. [58]

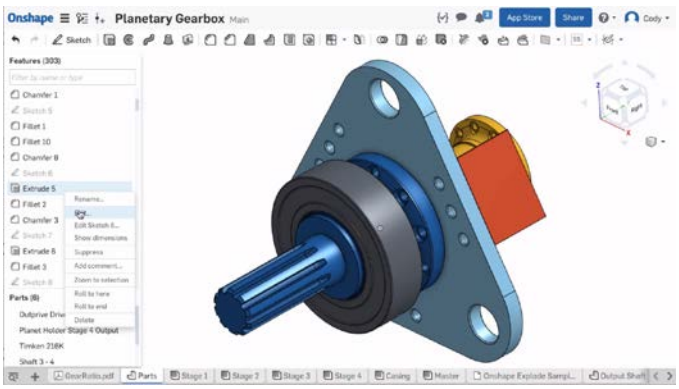

Fig. 22 OnShape [58]

V. Conclusion

This article lists the 20 most popular 3D Modeling Software for 3D Printing. Almost 20 is many software. The 3D model builder must go a long way before choosing 3D Modeling Software for 3D Printing that is ideal for his needs. This overview is intended to assist with this selection. This citation of journal articles can be selected using 3D Modeling Software for 3D Printing in scientific journals. It is therefore up to each 3D Modeling Software for 3D Printing to choose. Whether he uses an unscientific journal overview or overview based on the number of citations in the scientific journals.

Acknowledgment

The paper has been supported by Specific Research Project of Faculty of Science, University of Hradec Kralove, No. 2102, 2017.

References

[1] CHIEN, Yu-Hung. Developing a Pre-engineering Curriculum for 3D Printing Skills for High School Technology Education. Eurasia Journal of Mathematics Science and Technology Education, 2017, 13.7: 2941-2958.

[2] BAYRAKTAR, Ömer, et al. Experimental study on the 3D-printed plastic parts and predicting the mechanical properties using artificial neural networks. Polymers for Advanced Technologies, 2017, 28.8: 1044-1051.

[3] YAMPOLSKIY, Mark, et al. Using 3d printers as weapons. International Journal of Critical Infrastructure Protection, 2016, 14: 58-71.

[4] THOMAS, D. J. 3D Printing. Printing on Polymers. Fundamentals and Applications, 2016, 293-306.

[5] RepRap [online]. 2017 [cit. 2017-10-31]. http://reprap.org/

[6] JONES, Rhys, et al. RepRap–the replicating rapid prototyper. Robotica, 2011, 29.1: 177-191.

[7] SELLS, Ed, et al. RepRap: the replicating rapid prototyper: maximizing customizability by breeding the means of production. World Scientific Book Chapters, 2009, 568-580.

[8] Strnadová V., Voborník P., Provazníková K.: Web Based Learning Method of Information Retrieval for First Year Students at University. In: DIVAI 2016 – The 11th international scientific conference on Distance Learning in Applied Informatics. Štúrovo, Slovakia: Wolters Kluwer, 2016, pp. 247–257. ISBN 978-80-7552-249-8, ISSN 2464-7470, e-ISSN 2464-7489.

[9] El-Hmoudová, D, Milková, E.: Computer-based testing in the field of foreign language assessment. In: Efficiency and Responsibility in Education 2012, Czech University of Life Sciences Prague, 2012, pp. 83–92.

[10] Strnadová V., Voborník P., Haviger J., Provazníková K.: Evaluation of Stress Conditions for FIM UHK Students in Order to Improve Blended Learning and Flexibility of Educational Process. In: Cheung S., Kwok L., Ma W., Lee LK., Yang H. (eds) Blended Learning. New Challenges and Innovative Practices (ICBL 2017). Lecture Notes in Computer Science, vol 10309. Springer, Cham, pp. 247–258, ISBN 978-3-319-59359-3, eISBN 978-3-319-59360-9, DOI 10.1007/978-3-319-59360-9_22.

[11] GRIFFEY, Jason. Creating and printing files. Library Technology Reports, 2014, 50.5: 16-22.

[12] AVILA, Lisa; BAILEY, Mike. A Computer Graphics Back-to-School Special. IEEE Computer Graphics and Applications, 2016, 36.5: 95-96.

[13] CHERRY, Michael Thomas. Design... Print... Animate. Indiana Libraries, 2016, 35.1: 13-17.

[14] BELTRÁN-PELLICER, Pablo. Modelado e impresión 3D como recurso didáctico en el aprendizaje de la probabilidad. Épsilon, 2017, 34.95: 99-106.

[15] Eva Milkova, Andrea Sevcikova (2016) Multimedia Applications: Graph Algorithms visualization. CINTI 2016 17th IEEE International Symposium on Computational Intelligence and Informatics 17–19 November, 2016 Budapest, Hungary, pp.231 – 236.

[16] KOPRDA, Štefan; TURČÁNI, Milan; BALOGH, Zoltán. Modelling, simulation and monitoring the use of LabVIEW. In: Application of Information and Communication Technologies (AICT), 2012 6th International Conference on. IEEE, 2012. p. 1-5

[17] Petránek, K., Janečka, P. and Milková, E. (2013) Testing programming aptitude: an in-depth analysis. In: Efficiency and Responsibility in Education 2013, Czech University of Life Sciences Prague, pp. 497–502]

[18] Hardware & Modeling Software for 3D Printing: 3D Printer Tools & Parts [online]. 2017 [cit. 2017-10-02]. http://www.inkpal.com/ink-news/3d-printer-hardware-modeling-software-tools-parts/

[19] Software For 3D Printing [online]. 2017 [cit. 2017-10-21]. https://3dprinting.com/software/

[20] Top 20: Most Popular 3D Modeling & Design Software for 3D Printing (2017 Update) [online]. 2017 [cit. 2017-10-21]. https://i.materialise.com/blog/top-25-most-popular- 3d-modeling-design-software-for-3d-printing

[21] 20 Best 3D Printing Software Tools (All Are Free) [online]. 2017 [cit. 2017-10-21]. Dostupné z: https://all3dp.com/1/best-free-3d-printing-software-3d-printer-program/

[22] Software & Tools [online]. 2017 [cit. 2017-10-21]. http://3dprintingforbeginners.com/software-tools/

[23] Google Scholar [online]. 2017 [cit. 2017-10-11]. https://scholar.google.com/

[24] Blender [online]. 2017 [cit. 2017-11-10]. https://www.blender.org/about/

[25] Blender [online]. 2017 [cit. 2017-11-10]. https://www.blender.org/

[26] SketchUp [online]. 2017 [cit. 2017-11-10]. https://www.sketchup.com/programs/sketchup-story

[27] SketchUp [online]. 2017 [cit. 2017-11-10]. https://www.sketchup.com/3Dfor/3D-printing

[28] SolidWorks [online]. 2017 [cit. 2017-11-18]. https://www.solidvision.cz/solidworks/

[29] SolidWorks [online]. 2017 [cit. 2017-11-18]. http://www.solidworks.com/sw/products/details.htm?productID=3879

[30] Fusion 360 [online]. 2017 [cit. 2017-11-18]. https://www.autodesk.com/products/fusion-360/overview

[31] Fusion 360 [online]. 2017 [cit. 2017-11-18]. http://help.autodesk.com/view/fusion360/ENU/

[32] Inventor [online]. 2017 [cit. 2017-11-18]. https://www.autodesk.com/products/inventor/overview#

[33] Inventor [online]. 2017 [cit. 2017-11-18]. https://damassets.autodesk.net/content/dam/autodesk/www/campaigns/inventor-resource/inventor-project-steering-knuckle-guide-updated.pdf

[34] Autodesk Maya [online]. 2017 [cit. 2017-11-18]. https://www.autodesk.com/products/maya/overview

[35] Autodesk Maya [online]. 2017 [cit. 2017-11-18]. https://www.autodesk.com/products/maya/features

[36] AutoCAD [online]. 2017 [cit. 2017-11-18]. https://www.autodesk.com/products/autocad/overview

[37] AutoCAD [online]. 2017 [cit. 2017-11-18]. https://www.cadlinecommunity.co.uk/hc/en-us/articles/203493352-AutoCAD-2016-Exclamation-marks-near-dimensions

[38] 3ds Max [online]. 2017 [cit. 2017-11-18]. https://www.autodesk.com/products/3ds-max/overview

[39] 3ds Max [online]. 2017 [cit. 2017-11-18]. https://www.autodesk.com/products/3ds-max/features

[40] Zbrush [online]. 2017 [cit. 2017-11-18]. http://pixologic.com/zbrush/features/overview/

[41] Tinkercad [online]. 2017 [cit. 2017-11-18]. https://www.tinkercad.com/about/features

[42] Tinkercad [online]. 2017 [cit. 2017-11-18]. https://www.tinkercad.com/
[43] Cinema 4D [online]. 2017 [cit. 2017-11-18]. https://www.maxon.net/en/products/cinema-4d/overview/
[44] Cinema 4D [online]. 2017 [cit. 2017-11-18]. https://cinema-4d.en.softonic.com/mac
[45] Rhinoceros [online]. 2017 [cit. 2017-11-18]. https://www.rhino3d.com/features
[46] Rhinoceros [online]. 2017 [cit. 2017-11-18]. http://www.malavida.com/en/soft/rhinoceros/#gref
[47] OpenSCAD [online]. 2017 [cit. 2017-11-18]. http://www.openscad.org/about.html
[48] OpenSCAD [online]. 2017 [cit. 2017-11-18]. http://www.openscad.org/
[49] MODO [online]. 2017 [cit. 2017-11-18]. https://www.foundry.com/products/modo
[50] Meshmixer [online]. 2017 [cit. 2017-11-18]. https://www.meshmixer.com/
[51] Meshmixer [online]. 2017 [cit. 2017-11-18]. https://www.meshmixer.com/design.html
[52] Sculptris [online]. 2017 [cit. 2017-11-18]. http://pixologic.com/sculptris/
[53] PTC Creo Parametric [online]. 2017 [cit. 2017-11-18]. https://www.ptc.com/en/products/cad/creo/parametric
[54] FreeCAD [online]. 2017 [cit. 2017-11-18]. https://www.freecadweb.org/
[55] FreeCAD [online]. 2017 [cit. 2017-11-18]. https://www.freecadweb.org/wiki/Screenshots
[56] Solid Edge [online]. 2017 [cit. 2017-11-18]. http://solidedge.com.au/
[57] Solid Edge [online]. 2017 [cit. 2017-11-18]. http://www.digitaleng.news/virtual_desktop/2010/03/solid-edge-with-synchronous-technology-2-first-encounter/
[58] OnShape [online]. 2017 [cit. 2017-11-18]. https://www.onshape.com/