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ANALYSIS OF FACTORS OF 3D PRINTERS FOR THE CREATION OF BRAILLE 3D MODELS

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In this scientific study, the optimization of the use of 3D printers is carried out. Because additive technology is developing quite actively, and at the same time, 3D printers are being actively created, with various technologies for creating three-dimensional models. Each 3D printer has its own features, advantages, and disadvantages. Every user has a question about selecting a 3D printer. Everyone has their own production needs and requirement, because printers are used in many industries, from mechanical engineering, aerospace, building construction to use in inclusion. This study focuses on the use of 3D printers for inclusion, to create three-dimensional models with Braille. This research paper aims to explore the advantages and limitations of using 3D printers for creating three-dimensional Braille models and to optimize their use. This article examines the advantages of using a 3D printer for the creation of Braille models. It also describes the potential pitfalls and limitations of using a 3D printer for the creation of Braille models and how the 3D printer can be optimized for this purpose. By analyzing the advantages and limitations of using 3D printers for the creation of 3D Braille models, this research paper aims to provide insight into how 3D printers can be optimized for the creation of Braille models. Software for producing Braille and the main 3D printers that can be used to create Braille models are also analyzed. Obtaining valuable information is the optimization and selection of 3D printers for creating models with relief dot font and understanding the principles of work for creating models. Using 3D printing technology, one can ensure high quality and accuracy of printing, personalize the material according to the needs of users, and quickly and efficiently produce prototypes and finished products. However, in order to fully exploit the potential of this technology, the necessary knowledge and skills are required, as well as an initial investment in equipment. Further research aims to explore software for modeling complex Braille models and slicer programs for 3D printing output, which will allow for some standards to be established for creating models for inclusion for people with visual impairments.

Keywords: *3D printer, 3D-models, factor, inclusion, 3D printing, additive technology, software.*

Formulation of the problem. With the development of additive technology, many 3D printers are being created that are able to cover certain needs of the production sphere. Each 3D printer has both its advantages and disadvantages. For example, as researched in this paper, emphasis is placed on the use of additive technology in inclusion, creation

of models with Braille font, there is a problem with the selection of 3D printers and creation of models.

Analysis of recent studies and publications. Most of the scientific articles superficially describe the technology of additive manufacturing, the emphasis is mostly on the field of medicine. However, additive technologies are used not only in medicine, but also in many other areas of industries. The scientific publication does not adequately describe additive manufacturing technology and recommendations for optimizing 3D printers for creating three-dimensional models with Braille, which is our main topic of scientific research. There is a need to conduct an analysis and establish standard recommendations for the use of 3D printers to create models with Braille. From here, one will be able to obtain results and information about the shortcomings of existing additive manufacturing for inclusion and help to find new ways and standards of additive manufacturing in the field of inclusion for people with visual impairments.

Presentation of the main research material

The use of 3D printers has revolutionized the way of creating three-dimensional models. In recent years, there has been growing interest in using 3D printers to create Braille models. The ability to tactilely represent objects and text has significant implications for people with visual impairments, and 3D printing offers several advantages, making great strides in the world of tactile graphics. For example (image 1), 3D printing can create three-dimensional models [1]. This technology also allows the use of multiple materials that can create more accurate tactile symbols [2]. In addition, 3D printing allows creating models in Braille with greater accuracy [3]. With the help of 3D printing, it is possible to reproduce the tactile relief-dot Braille font using flexible settings and different levels of relief lines [4]. This technology also led to the development of prototypes and dual-purpose models such as Braille and painted relief images [5]. Braille can also be added to 3D printed models [6], which can be used for educational purposes and to assist the visually impaired [7]. 3D printing can also be used to create material models of three-dimensional digital virtual models, thereby helping the use in the fields of services, education for accessibility for people with visual impairments [8]. As a result, 3D printing has become a powerful technology, including in the world of tactile graphics, which facilitates the creation of three-dimensional Braille models [9]

The cost-effectiveness and accuracy of 3D printing technology have made it a popular choice for creating practical Braille models [3]. Studies have shown that 3D printed maps have a number of advantages for visually impaired people compared to traditional prototyping techniques [1] 3D printing can create more detailed and complex tactile graphics than those produced by standard Braille embossing [4]. In addition, 3D printing can be used to create large models that can be used to teach the periodic table to visually impaired people [5]. Additive manufacturing also has the ability to create tactile symbols such as Braille with 3D printers that can be used to help visually impaired people understand written information [8]. 3D printing technology therefore has several applications to improve the readability of Braille for the visually impaired. 3D printing technology was used to make tactile maps for visually impaired people from all over the world [6]. 3D printing can facilitate the production of tactile symbols [6]. This process

can be improved to create interactive physical models for blind people [6]. Furthermore, 3D models can be used as an accessibility tool for the visually impaired [6]. In addition to the advantages of using multiple materials, 3D printing technology allows for complex prototypes and can be used to create tactile symbols for maps, diagrams and labels [6]. The 3D printing process is also more cost-effective and faster than other traditional methods [6]. Let one look at an example of a 3D bee model, which is often compared to modeling Braille prototypes.

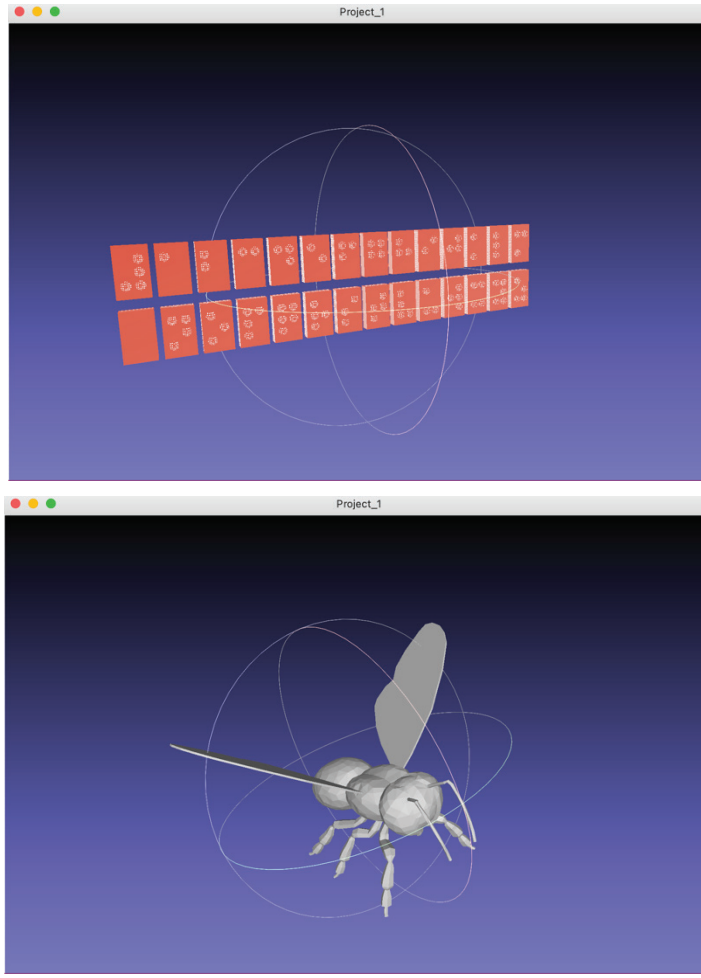

Image 1. Example 3D-model with Braille font and 3D-Bee

1. Both have structures that reduce problems. 3D bee printing creates a three-dimensional bee model with both convex and concave parts. Braille also uses raised letters so that the visually impaired can recognize writing.

2. Both require precise placement When 3D printing bees, it is very important to precisely position the layers of material to create a realistic model. When printing Braille, it is also very important to place the dots correctly to facilitate reading.

3. 3D printing can be used to create models for visually impaired people to observe the anatomy of a honeybee. Braille is used to create books, periodicals and other printed materials for the visually impaired.

4. 3D printing can create a range of objects useful for the visually impaired. Braille is very important for the visually impaired and enables them to read and write. Overall, 3D printing and Braille are technologies that share several similar characteristics. Both require elevated structures, are precise in their placement, and are used to create accessible objects.

Other similarities.

- Both can be used to create tactile objects that can be used by the visually impaired.
- Both can be used to create custom objects.
- Both can be used to create both practical and aesthetic objects.

Differences.

- 3D printing of bees is a recently developed technology, whereas Braille has been around for over 100 years.
- 3D printing of bees is used to create 3D objects, whereas Braille is used to create 2D objects.
- 3D printed bees are more expensive than Braille books.

Ultimately, 3D printing, and Braille are different techniques that can be used to create portable and functional objects. This formulated the later design of a three-dimensional bee model (3D-bees) for a specific Braille system [6]. The 3D bee was used in conjunction with a 3D printer and was placed alongside its Braille printers, allowing users to access 3D tactile symbols [6]. This technology has been approved by Braille authorities as an effective tool for tactile graphics [6]. Thus, 3D printing can provide an efficient, cost-effective, and efficient way to produce tactile maps and symbols for the visually impaired [6]. 3D printers have limitations when it comes to creating 3D Braille models that are tangible and can be read by visually impaired people. This is due to the difficulty of placing the model in the space of the replicator in such a way that the supports do not affect the inscriptions [10]. In addition, the supports can damage the inscriptions if they are removed [10]. The scientists chose an inverted position to minimize the amount of resistance generated [10]. In addition, only digital waterproof models can be processed by 3D printing [10]. Moreover, there may be surface geometry errors that cause problems in the printing process [10]. These issues make it difficult for 3D printers to create 3D Braille models suitable for visually impaired people [10]. 3D printing is a promising technology that offers several advantages for the creation of haptic 3D models [3][11], but there are also potential disadvantages to consider when creating models. For example, 3D printed models can provide a tactile experience, but may lack the detail necessary for easy understanding [12]. These limitations make 3D Braille models difficult to read and understand [1][6]. Furthermore, 3D printing is expensive and difficult to use, making it difficult for people with limited resources and technical knowledge to use this technology [2][10]. Furthermore, both the resolution of 3D printers and the size of 3D printed models are limited [6]. These problems are further complicated by the fact that Braille does not yet have standardized symbols [9]. As a result, 3D printed Braille

models need to be complemented with dual-purpose designs (Braille font and painted text) [7]. In conclusion, it is possible to create 3D printed Braille models, but there are several potential challenges, including limited details, lack of standardization, cost and complexity of the technology, that must be taken into account. 3D printing has become known as a powerful tool for creating material models, and Braille models are no exception. [3] This technology can be of great benefit to the visually impaired by providing them with tactile maps, prototypes, models, and tactile labels for learning and reading information from the environment [1]. They are also used to make 3D printed bees for educational purposes. [2] 3D printers are useful machines that can be used to create objects using programmable commands. [11] Although 3D printing is a viable technology, there are some limitations when it comes to adding Braille labels to 3D printed models. Indeed, most 3D printers have limitations in terms of print quality and model design [7]. Furthermore, there are specific rules for Braille in tactile graphics. [9] With this in mind, 3D printing has been used to create Braille on models through scanning and modeling [10]. It is worth noting that 3D models have the potential to be interactive for visually impaired people [12]. In a study to evaluate the effectiveness of 3D printed models, 11 participants, four of whom were visually impaired, were familiar with Braille [12]. The findings suggest that 3D models can improve accessibility for visually impaired people [12]. Also in this study, four postures and their benefits were identified to help determine the effectiveness of 3D printed models in assisting visually impaired people [12]. Thus, 3D printers can be optimized to create Braille models for the visually impaired. 3D printing as a technology that produces physical objects from digital models by appending layers of material to one another. 3D printing can reproduce three-dimensional models in Braille, where there is an opportunity to form relief-dotted Braille for the visually impaired. Such three-dimensional models are tactile and enable information to be read by visually impaired people and used for teaching in inclusive education. 3D printing, like other production technologies, has its advantages over other Braille production methods, such as:

- Effectiveness: 3D printing can lower the expense of Braille materials by utilizing less equipment and energy, it also eliminates the need for expensive machines or instruments.
- Accessibility: 3D printing can facilitate the creation of Braille materials that are more accessible by allowing users to create their own labels or signs, without having to rely on external providers or having to wait for a delivery.
- Flexibility: 3D printing can have a greater degree of flexibility in creating Braille materials, this is accomplished by allowing users to customize the size, shape, color, and design of their models, additionally, it can create complex tactile graphics.

To create 3D printed Braille models, users need a 3D printer, a 3D model and software to create and download the model. Many different types of 3D printers exist, including FDM, SLA, and SLS, which utilize different materials that are completely different from plastics, resins, metals, and have different levels of resolution, speed, quality, and accuracy. The choice of a 3D printer is based on the personal preferences of users. There are certain factors to consider when choosing 3D printers to create 3D Braille models.

– Resolution: The resolution of a 3D printer is the smallest amount of parts that can be produced and is measured in microns. The higher the resolution, the better it provides higher quality, accuracy, and a smooth surface, which is quite an important factor when creating Braille models, because the raised dots need to be clear and consistent in order for a visually impaired person to be able to read the printed information. Basically, SLA and SLS 3D printers have a higher resolution than FDM printers, but they are also more expensive and require more processing after printing.
– Speed: The speed of a 3D printer is the rate at which it prints a model, expressed in millimeters per hour. A faster speed is associated with a shorter printing duration, which is beneficial to Braille models, which are typically small and simple. However, speed also has an effect on the quality of the print faster speeds can lead to lower resolution or accuracy. FDM printers are typically faster than SLA and SLS printers, but they also have a lower resolution and fidelity.
– Accuracy: The accuracy of a 3D printer is the degree to which it can replicate the dimensions and shape of the 3D model, expressed as a percentage or in millimeters. The higher the accuracy, the more accurate the representation of the model. This is very important because Braille models require the size and spacing of dots to be determined according to Braille standards; SLA and SLS printers are generally more accurate than FDM printers, but require more calibration and attention; FDM, SLA, SLS etc.

There are many different types of 3D printers, most of which use very different substances and materials, such as plastics, resins and metals. These materials have their own levels of resolution, speed and accuracy. Choosing the most effective 3D printer for creating Braille models depends on personal needs and what three-dimensional models will be created. There are three factors to consider when choosing 3D printers to create 3D Braille models:

Ease of use. The greater ease of use of information systems leads to easier paths, which are beneficial for Braille models since they have a convenient and simple interface, which reduces the time and cost of user training. Touch See is a software application that allows users to enter text into a blank space, generating it in Braille and creating a 3D model that can be saved in STL format and ready for 3D printing.

Customization. The customization process involves changing software features, capabilities, or parameters to make them more personal or modified. Optimized settings and customization is beneficial for 3D Braille models as it allows for more flexible and creative modeling by allowing changes in size, shape, color and design. OpenSCAD is a highly customizable software that allows users to modify models using a scripting language, various parameters such as point size, spacing, height and shape.

Variety. Software variety is the number of different models supported or provided by the software, expressed as number of categories, formats or sources. More variety means more variety and more diverse and complex choices, this is advantageous for Braille models that may contain additional components such as labels, graphics or objects. However, there are many programs and web services that provide ready-made 3D

models in Braille, certain text, objects, etc. For example, software such as Cults3D and CGTrader are web-based platforms that have a large library of ready-made 3D models for Braille and with the font, which can be downloaded from the web platform in ready-made formats such as STL, OBJ or GCODE. But there is such a service as Touch See, where it is possible to write plain text generated by the Braille font into a ready-made standard rectangular 3D model and with the possibility of loading it in STL format, ready for 3D printing.

Conclusion. The study examines the use of 3D printing technology for creating three-dimensional Braille models and identifies its advantages and limitations. According to the results of this scientific research, it is determined that additive manufacturing, or in other words, 3D printing, is a justified use for creating tactile three-dimensional models, since 3D printing has the ability to reproduce sufficiently high-quality relief-dotted points of Braille font (symbols, letters, etc.) and reproduce on various materials, such as plastic, metal, polymer materials, etc. The use of 3D printing in the field of inclusion is quite financially and economically profitable, compared to other traditional types of production. Such production allows rapid creation of tactile models and accelerates the development of inclusion for people with visual impairments. However, additive manufacturing also has its drawbacks when used in the field of inclusion for people with visual impairments. This is the occurrence of shortcomings in the formation of Braille, especially voluminous and complex texts and the interpretation of tactile models, which requires certain testing of tactile models by people with visual impairments, as well as the wear resistance of materials in real life conditions. For this, it is necessary to conduct scientific research and conduct experiments with materials for 3D printing and create new information systems for the analysis of three-dimensional tactile models even before the launch of 3D printing. In addition, the research opens up the prospect that 3D models can also be interactive, allowing for increased inclusion and accessibility for people with visual impairments. Based on the findings, 3D Braille models are just one type of object that can be created using 3D printing technology; however, more research is needed to determine the full potential and limitations. The obtained research results in this scientific article will give impetus to the further development of scientific research in the field of additive manufacturing to create tactile models with relief-dot Braille for people with visual impairments and are useful for future experiments as well as practical applications aimed at improving inclusion and accessibility for people with visual impairments. In general, it is considered how additive manufacturing and the choice of 3D printing materials can affect the creation of models or prototypes with Braille. In addition, this study shows that 3D printing technology can be optimized to create Braille models, but further research is needed to explore its full potential and address any limitations. The results of this research can contribute to the further development of additive manufacturing and improve the quality of creating tactile models for people with visual impairments using 3D printing and improve the quality and expand inclusion and accessibility in all areas of life for blind people.

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АНАЛІЗ ФАКТОРІВ 3D-ПРИНТЕРІВ ДЛЯ СТВОРЕННЯ 3D-МОДЕЛЕЙ БРАЙЛЯ

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У цьому науковому дослідженні було проведено оптимізацію використання 3D-принтерів. Оскільки досить активно розвивається адитивна технологія, а разом з тим активно створюються 3D принтери, з різними технологіями створення тривимірних моделей. Кожен 3D-принтер має свої особливості, переваги та недоліки. У кожного користувача виникає питання про вибір 3D принтера. У кожного свої виробничі потреби та загальні потреби. Тому що принтери використовуються в багатьох галузях промисловості, від машинобудування, аерокосмічної промисловості, будівництва до використання в інклюзії. Це дослідження зосереджено

на використанні 3D-принтерів для створення тривимірних моделей за допомогою шрифту Брайля. Ця дослідницька стаття має на меті вивчити переваги та обмеження використання 3D-принтерів для створення тривимірних моделей шрифтом Брайля та оптимізувати їх використання. У цій статті розглядаються переваги використання 3D-принтера для створення моделей Брайля. У ній також описуються потенційні проблеми та обмеження використання 3D-принтера для створення моделей Брайля а також способи оптимізації 3D-принтера для досягнення високої якості відтворення брайлівських моделей. Аналізуючи переваги та обмеження використання 3D-принтерів для створення 3D-моделей Брайля, ця дослідницька стаття має на меті дати розуміння того, як 3D-принтери можна оптимізувати для створення моделей Брайля. Також проаналізовано програмне забезпечення для створення шрифтом Брайля та основні 3D-принтери, які можна використовувати для створення моделей шрифтом Брайля. Отримання цінної інформації полягає в оптимізації та підборі 3D принтерів для створення моделей з рельєфним крапковим шрифтом та розуміння принципів роботи для створення моделей. Використання 3D-принтерів для моделювання шрифту Брайля відкриває нові можливості для створення доступних і зрозумілих матеріалів для людей з порушеннями зору. Використовуючи технологію 3D-друку, ви можете забезпечити високу якість і точність друку, персоналізувати матеріал відповідно до потреб користувачів, а також швидко і ефективно виготовляти прототипи і готові вироби. Однак для того, щоб повною мірою використати потенціал цієї технології, потрібні необхідні знання та навички, а також початкові інвестиції в обладнання. Подальші дослідження спрямовані на вивчення програмного забезпечення для моделювання складних моделей Брайля та програм розрізання для 3D-друку, що дозволить встановити деякі стандарти для створення моделей для включення людей з вадами зору.

Ключові слова: *3D-принтер, 3D-моделі, фактори, Брайля, інклюзія, 3D-друк, адитивна технологія, програмне забезпечення.*

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