Uniport Journal of Engineering and Scientific Research (UJESR)

Vol. 7, Issue 2, 2023, Page 91-98
ISSN: 2616-1192

(www.ujesr.org)

Computer And Society and its Application in Industrial Design of Ceramics: A Review

Alewai, M.J
Department of Industrial Design Faculty of Environmental Design Ahmadu Bello University Zaria
*Corresponding author's email: mamalewai61@gmail.com

Abstract
Computer graphics has found many applications in various fields in recent years. Industrial design is an important task in developing many manufactured products. This paper discussed computers and society, the interaction of people and computers, the impact of computers on various people, information security, personal privacy and future trends. It discussed how computer graphics and Computer Aided Design (CAD) can be used to simulate the physical properties and behaviour of ceramic materials, how computer graphics and CAD can be integrated with other emerging technologies, such as 3D printing, virtual reality, and artificial intelligence, and how computer graphics and CAD can support or enhance these technologies for ceramic applications. Furthermore, this paper provided a comprehensive overview of the current trends and innovations in computer graphics and CAD for ceramic industries and compared their advantages and disadvantages.

Keywords: *Design, Ceramic, CAD, Graphic, Product, Technology*

Received: 8th June, 2023 *Accepted: 14th September, 2023*

1. Introduction

Any application of computers in the public sector could illustrate how computers affect the way society operates. Examples of such computers are used to process social security payments, help administer hospitals, maintain lists of persons wanted by law enforcement and aid in the drafting of legislation. The study of computers and society then includes an analysis of how computers influence the operation, shape, and especially the goals of political, social and cultural systems (Kaczmarczyk, 2012). To put the subject in perspective, it is necessary to recognise that computer functions in the large area of automation and automation are only one although a key one of several technological forces that are reshaping society (O'Callaghan, 2020). Other key technological developments are occurring, for example in transportation/communications (jet air travels, space flight, and cable TV satellite transmission), in biology, medicine, contraceptives, transplants, drug experimentation, and tic engineering and so on.

Computers brought about a change in the composition of the labour force. It affected the number of workers in industrial countries engaged in farming, textile production and mining (primarily industries). However, it increased the number of those engaged in manufacturing (secondary industries). Computers generally gained acceptance within a very few years, and the rest is technological displacement and hardship for those with specialised skills in the industries (Badu-Nyarko, 2012).

Along with the benefit of the Industrial Revolution which originated in Europe during the 19th century, there were widespread harmful effects, including serious displacement of labour because of the introduction of machines and concentrated urban pollution due to the uncontrolled production of waste products. The introduction of machinery gave rise to such events as the protests of the Luddites, who in 1811 and 1812 broke into factories and smashed machines that threatened their jobs, and the writing of Samuel Butler, who in 1872 published Erewhon, a novel about a utopia where all the machines were banished because only in this way could the society be certain that machines would not eventually take over control.

Different groups of people have different ways of defining, understanding, and using computers. For example, a computer scientist might define a computer as a device that can be programmed to perform logical or arithmetic operations, while a graphic designer might define a computer as a tool that can create and manipulate visual images. A

historian might define a computer as a machine that has evolved from mechanical calculators to electronic devices, while a gamer might define a computer as a platform that can run various types of games.

The research project between Helsinki University of Technology and O.Y. Arabia Ab was launched in 1985 to apply computerized design techniques for Arabia's production of ceramic tableware. The project aimed to develop a system that could generate and manipulate three-dimensional models of ceramic objects and print them on a plotter. The project also explored the artistic and aesthetic aspects of computer-aided design for ceramics (Orkas et al, 1987). It was taken as a specific goal to produce a three-dimensional Computer Aided Design (3D CAD) system to be used directly by the designers, instead of having to involve computer engineers in the creative design process.

Computer graphics and computer-aided design (CAD) are two fields of computer science that deal with the creation, manipulation, and visualization of graphical objects and models. Computer graphics and CAD have many applications in various domains, such as engineering, architecture, art, entertainment, education, and science (Wong and Hernandez, 2012; Berman, 2012). One of the domains that can benefit from computer graphics and CAD is the ceramic industry, which is the production of pottery, porcelain, and other products made from clay or other inorganic materials.

The ceramic industry is an important sector of the economy and culture of many countries (He, 2022). Ceramic products have various uses and functions, such as tableware, tiles, sanitary ware, art objects, and ornaments. Ceramic products also have aesthetic and artistic value, as they reflect the creativity and craftsmanship of the designers and makers. However, the ceramic industry also faces some challenges and limitations, such as high production costs, environmental impacts, quality control, and market competition (Zhang et al., 2021).

Therefore, there is a need to explore how computer graphics and CAD can improve the design process and the quality of ceramic products. Computer graphics and CAD can offer some advantages over traditional methods of ceramic design, such as faster prototyping, easier modification, higher accuracy, lower waste, and more diversity. Computer graphics and CAD can also enable new possibilities and innovations for ceramic design, such as integrating with other emerging technologies, such as 3D printing, virtual reality, and artificial intelligence (Bose et al., 2013).

The main research question that this paper addressed is: How can computer graphics and CAD be applied to ceramic design? To answer this question, this paper discussed the following aspects: (1) How computer graphics and CAD can be used to simulate the physical properties and behaviour of ceramic materials, (2) How computer graphics and CAD can be integrated with other emerging technologies, such as 3D printing, virtual reality, and artificial intelligence, and (3) How computer graphics and CAD can support or enhance these technologies for ceramic applications. Furthermore, this paper provides a comprehensive overview of the current trends and innovations in computer graphics and CAD for ceramic industries and compares their advantages and disadvantages.

2. The interaction of people and computers

The computer system has an important role to play in enabling the organisation it serves to meet this goal. The role of computers in society is a large subject to consider. Computers play a role in determining the balance of powers because they are such powerful instruments for gathering, organising and disseminating information. Sociologists and political scientists have come to recognise that information is a new source of power, complementing the traditional sources of land and capital. The possession, distribution, and utilisation of information are seen as a new major activity comprising what has been called the "knowledge industries". Many people are engaged in these industries. Scientists, Engineers, Mathematicians, Librarians, Teachers, Reporters, Planners, Management consultants, etc. Computer and computer personnel form only a part of the information-gathering activities, but they are an important part because information gathering and processing are the central functions of a computer. Many participants in knowledge industries use computers in their respective specialities.

The fact that computers are used by librarians for information retrieval, by teachers in computer-assisted instruction, by lawyers looking for a legal precedent, or by politicians for overall campaign management, including budgeting, scheduling, and coordinating staff and volunteers, is, of course, important for all of these activities stated and how the effectiveness of information gathering is enhanced. Beyond these direct benefits are indirect effects whereby the presence of computers in some ways alters the climate in which things are happening. These indirect or secondary effects may,

in the long run, be more important than the primary ones (Sichel, 1997).

The communication system is most promising in this regard as well and the mobility aspect is also a very vital issue. The most beneficial categories of the people in this function are disabilities. For example, according to Oestreich (1993) and Thomson (1995), there are possible disadvantages to some aspects of the technology. They noted that although technologies like the internet make learning and employment more accessible to people with disabilities, such technologies may isolate the user by regulating distance learning teleworking modes. It must be remembered that although computers do assist people with disabilities, they are just one tool in the wider process of achieving the same quality of life enjoyed by those le without disabilities (Hurt, 1996).

The relationship between people with disabilities and the rest of society has always had an ambiguous dimension. On one hand, the disabled depend on and appreciate the assistance of others in compensating for their disabilities, but on the other hand, they often feel that the negative attitudes towards them held by society serve to increase their disabilities and enlarge their sense of powerlessness and dependence. This frequently places the disabled person in the position of needing help, while simultaneously representing the helper (Scott, 1969). Transcending the disability through developing new personal skills or creating tools which compensate for the disability becomes one key way to escape from this trap.

3. The impact of computers on various people

Computers are just one example of automation although they have many specialised features. In a society that relies heavily on all forms of automation and automated handling of information, computers are bound to be very important issues related to jobs, and privacy is particularly significant. Information technology is having an impact on individuals, organisations and society. The fact that so few remain in manufacturing, although manufacturing continues to generate wealth, has led to society today being called a "post-industrial society". The national and international community of governments, businesses, organizations, and individuals are increasingly dependent on communication, processing and storage of information for various purposes, such as governance, trade, education, research, entertainment, and social interaction. Some people have claimed that we are moving towards an "information society", in which the majority of the labour force will be engaged in information processing and the use of information technology.

Computers are like other technologies and will have similar effects, but are the first and only general-purpose technology and therefore have more potential than other forms of technology. With the advent of artificial intelligence (AI), which is the ability of a computer or a machine to perform tasks that normally require human intelligence, such as reasoning, learning, decision-making, and problem-solving, computers are getting more intelligent, they are more like humans (Copeland., 2023). Computers have put people out of the workplace because they lead to greater efficiency and productivity. Only a few workers are required on the computers instead of many workers. The use of AI could have a disastrous impact on unemployment, as it could replace human workers in many sectors and industries. There are demands for a few products and services in industries that have not existed before. Most of the occupations held today did not exist a hundred years ago. No guarantee of a new job. Skills need to be current and government support is necessary. New technologies are likely to affect almost every part of our lives (Butler, 1996). Voice recognition software, scanning technology, increasing use of e-mail and other forms of electronic data transfer and an ever-expanding range of assistive devices have enabled increasing numbers of people with disabilities to retain and enter the labour market (Workbridge, 1996)

4. Information security and crime

The 1984 Data Protection Act intended to regulate the use of automatically processed information relating to individuals and the provision of services in respect of such information by imposing certain obligations on data controllers and data processors. Some people who used to enjoy the freedom of using computer applications have felt let down and disheartened by the act, which restricts how their personal information can be processed and shared. The act requires those with personal data to register with a data protection registry for their data security. The deadline was set for April ending 1986. Experts were responsible for the act to avoid mistakes.

Three aspects of computer crime are often reported in the media and deserve a mention here because of their social importance. They are: (1) Hacking and computer fraud, (2) Computer viruses, and (3) Copyright privacy. According to Westin (1970), "The Court's closing statement reaffirmed

the right of an individual to have his personal information kept private, and hinted that systems where information is not secure may not pass the test of reasonableness." The collection of taxes, the distribution of welfare and social security benefits, the supervision of public health, the direction of our armed forces, and enforcement of the criminal laws, all require the orderly preservation of great quantities of information, much of which is personal in nature and potentially embarrassing or harmful if disclosed. The right to collect such data for public purposes is typically accompanied by a concomitant statutory or regulatory duty to avoid unwanted disclosure

Computers without any means of security are vulnerable to attacks from viruses, worms, and illegal computer hackers. If the proper steps are not taken, safe computing may become a thing of the past. Many security measures are being implemented to protect against illegalities. The Computer Misuse Act, 1990: Hacking, computer fraud and computer viruses are all relatively crimes that established English laws were not designed to deal with.

5. Computer and privacy

Another consequence of higher levels of computerisation is the increase in the use of computer-based equipment to store large quantities of data about individuals. Some of this data is of a particular or private nature and there is a natural concern that it should not be misused. There is also concern that individuals may also have personal information stored about them without their knowledge or control and that it may be hard or impossible to find out whether such information is accurate (Auxier et al., 2019).

In 1975, a government white paper considered this issue and in 1976, a committee was set up and chaired by Norman Lindop. The idea was that systems dealing with records containing personal details should be controlled. The Lindop Report appeared about two years later and was well received, It establishes several principles e.g., that stored data should only be used for the purpose for which its use was originally authorised and intended. The report suggested that a Data Protection Authority (DPA) should be set up which would enforce codes of conduct for different types of systems.

At about the same time, the Council of Europe set up a "convention for the protection of individuals concerning Automatic Processing of Personal Data". Each country signs twice, once to agree to legislate and the second time when it has been legislated. Britain had only signed once by early 1984 and computer organisations such as BCS (British Computer Society) and CSA (Computer Services Association) had expressed fears that delays could cost the UK dearly in terms of lost international contracts through failure to introduce legislation. Such legislation is the primary responsibility of the home office itself an important user of computer data banks of a usual kind, e.g., those concerned with police records like those held on the Police National Computer at Hendon (North London). The criminals can take advantage of the unwary uniforms transmitted and store sensitive information about millions of people but will be punished for violations. Hopefully, the law will serve as a deterrent.

6. Computer and future trends

The first and most important trend is for the computer industry to engulf and devour everything else. Serious electronic computing started with ideas such as calculating the trajectories of artillery shells. Processing numbers taken is through stock control and payroll, then into word processing. Serious graphics that started with computer-aided design took us through desktop publishing to photorealistic graphics, desktop video and digital television. Speech and music were synthesised and digitised along the way. As Negroponte (1995), founder of the MIT Media Lab, has pointed out, the world of atoms is being replaced by a world of bits-the binary digits of computing.

The second trend is for specialisation. As the computer ecology gets bigger and richer, it can support more types of devices aimed at more specialised riches. For example, you can get Windows PCs in formats ranging from portables to mainframe-class systems via an incredible variety of notebooks, laptops, desktops, and deskside services. The phone industry is being absorbed into the computer industry. Phones are increasingly using computer processors, commonly referred to as mobile processors or system-on-a-chip (SoC). These processors are designed specifically for mobile devices and combine various components onto a single chip, including the central processing unit (CPU), graphics processing unit (GPU), memory, connectivity modules, and other integrated circuits. While the old phone networks are replaced by packets of data being sent from computer to computer (e.g., Voice Over Internet Protocol, VOIP). This absorption is stimulating a sort of Cambrian explosion of new phones, cameras, music players, built-in TV sets, and digital assistants like Google Assistants, Amazon Alexa, etc.

The third trend is for power to move from the centre to the edge of the network. We used to live in a world where networks were big and powerful and the devices were dumped: think of a TV set or a Black Bakelite phone. Today, the power is in the devices that are attached to the network - the smartphones and TiVo-style television sets, while the networks are becoming much less powerful. Indeed, people increasingly want their devices to be physically detached from the network, wireless and able to connect to multiple networks at once. Think of replacing one wire with Bluetooth, GPS, GSM, Wi-Fi, WiMAX, DAB and Smart television. Every few years there are campaigns for things like "utility computing" where companies want to move all the power back to the centre, leaving users with the equivalent of dumb terminals. In some ways, it is an attractive idea.

The Current rapid rate of computerisation and technical innovation has brought about a "micro-electronics revolution". To others, these changes are merely viewed as another phase in the process of automation which started with the industrial revolution. Either way, it seems reasonable to expect change and yet more change in the future. The "fifth generation" supercomputers are well here, whether these computers will cause delight or dismay, the answers do not rest in the technology.

The advantages of computers to societies are many for example job opportunities for different people with disabilities. New jobs that were not available before were created. Communication systems are easier, transportation is easier and faster, designs and colours are easier to obtain, and computer owners/users are making benefits and gains. The functionality is superb for performing a variety of sophisticated roles through the storage of large volumes of data on the hard disk and the use of appropriate software programs. The speed at which computers perform saves a lot of precious time for the researcher. There is complete accuracy because the computer could be said to be errorless. However, if the researcher injects garbage into the computer, he can only expect garbage as output. Access to computer services is no longer a problem since microcomputers have become part of personal belonging in various homes. It is even becoming a necessity that all students and staff of our tertiary institutions should be computer literate. This will enable them to take advantage of the services of the computer, particularly in analysing research data

Disadvantages of computers include occupying many job opportunities for other people. It can fail some Data (no guarantee). It exposes the privacy of individuals and it also corrupts different kinds of society by exposing them to the corrupt aspects of other cultures, especially the youths of the generation.

7. Computer-aided design and ceramics

Besides good design and quality, the ability to present novelties faster than before became an important competitive factor in the ceramic industry. However, both product development and manufacturing are complex and time-consuming processes involving a lot of shifted manual labour. Getting the right form into clay requires constant negotiations with the designer and the model maker, and predicting the material deformations at high temperatures usually takes several experiments before the desired form comes out of the kiln. The manufacturing of the fire prototype for a single non-rotational object takes therefore several weeks.

A complete dish set consists of several pieces, where not only the properties of individual parts need careful consideration, but also their shapes and sizes are related to each other. Most of the prototype models never appear in the market but are discarded in early product development stages, either by the designer, the production manager, or the marketing people.

The bulk of the product development is not only in the difficult manufacturing processes but also in the decision-making at the various levels of production. With all the production interactions involved, it typically takes two to four years to carry out a set of dinnerware from the design idea into a complete product in the market.

Several weeks and usually even seven months of savings in production time can be gained by employing 3D CAD technologies in the early product development phase. Modern 3D CAD software enables designers to visualise their design ideas faster than before, thus easing the communication between different production levels already before the prototypes are made (Riihimäki and Tuomi, 2005).

Taking 3D CAD to the production already in the early design stages can also improve the quality of the products. With manual working methods, it would not be reasonable to ask the model to make a quantity of mirrors or but time-consuming changes to the model, and something less perfect may have to be accepted due to the schedule. The CAD system allows the designer to go through all the variations he wants even before the prototype has to be made. Thus, the dimensions and computation of physical properties such as volumes can also be associated with the initial form-giving process.

For the most flexible production environment, the 3D CAD software should encourage the designers to define their ideas directly with the computer. For this to happen, the modelling methods must bear good intuitive correspondence to accustomed manual drafting methods, not demanding necessary numerical or mathematical manipulation. To rely on computer models for decision-making, the visualisation methods must provide an ultimate level of realism and textures.

8. Modelling techniques

Following the original request of ceramic tableware artists, the Desk Artes IDS system does not operate with 3D coordinate manipulation at all. Instead, all 3D models are conveniently defined by thawing simple 2D curves out at which complex free-form shapes are produced at the push of a button. For construction, the system automatically transforms the cross-sections between the profiles and the corresponding surface is computed to match all the given curves (Sorkine et al., 2004). This way 3D CAD is made easy, with most of the modelling, and interaction being concentrated in creature form giving a process with free-form curves. A plethora of curve editing tools have been developed in collaboration with design artists to support the design of curves with ease and precision. While the profile/cross-section method provides immediate correspondence with the designer's intuition of geometric description, it has also turned out general enough to cover the majority of modelling applications typically met in ceramics and glass tableware design. For some of the more demanding models, the Desk Artes IDS software also provides various higher-level tools to combine separately defined surfaces into one piece.

9. Visualisation

To serve the visualisation requirements at different levels of product design, methods with altering complexity are required. For the sketching phase of the design, open shading allows inspection of the geometric model from different views and close-ups in real-time. However, once the designer is happy with his design, the a need for a higher level of realism in visualization and final production and manufacturing judgement. The ray tracing method accounts for global illumination in the scene (Riihimäki and Tuomi, 2005), which is vital to the visualisation of complete dish sets with several pieces.

In the ceramic industry, the products are usually marketed with different patterns, sometimes exclusively for specific customers. Using Desk Artes IDS, texture mapping is finally used for adaptive mapping, colour image or bump mapping, up to high-end methods such as projector textures and surface flattering instead of having to manufacture all the alternative variations. Products can now be marketed based on computer image catalogues, and actual production begins only at the customer's order.

10. Future research focuses

i. Developing new methods and algorithms for simulating the physical properties and behaviour of ceramic materials using computer graphics and CAD. Ceramic materials are widely used in various industries, such as aerospace, energy, healthcare, etc., due to their high strength, hardness, thermal resistance, and biocompatibility. However, designing and manufacturing ceramic products is challenging, as ceramic materials have complex and nonlinear physical properties and behaviour, such as fracture, porosity, phase transformation, etc. Therefore, it is essential to have accurate and efficient methods and algorithms for simulating ceramic materials using computer graphics and CAD tools.

ii. Evaluating the social and ethical implications of computer graphics and CAD for ceramic industries. Computer graphics and CAD tools have revolutionized the design and manufacturing of ceramic products by enabling faster, cheaper, and more creative processes. However, these technologies also pose some social and ethical issues that need to be addressed, such as information security, personal privacy, intellectual property rights, environmental sustainability, etc. Therefore, it is important to have a framework or a method for assessing and balancing the social and ethical implications of computer graphics and CAD for ceramic industries.

11. Conclusion

The most important benefit of 3D CAD is faster product development that allows novelties to be presented in a shorter cycle, in turn leading to a greater richness of assortment. To fully exploit the method, the CAD word should be considered as a working tool for the original designers. The profile/cross-section techniques enable the designers to visualise their ideas with an immediate link from 2D sketches to 3D CAD models. High-quality ray-traced colour images of the computer model can then be immediately used to ease the communication between different departments and

people involved in product development, up to marketing and customer cases. Today, a company can save more than 50% of the total time when it uses CAD/CAI instead of traditional design and manufacturing methods.

There are merits and demerits of computers. The merits of computers are many to mankind these days. For example, it eases stressful mathematical calculations, printings, designs of different types, saves time, beautifies works (printed), stores documents, it is faster and so on. One of the challenges of using a computer is that it can be hard to learn how to operate it at first. It is also costly for the common man. The computer is so dumping, it can sometimes fail, it encourages isolation, and it makes certain sectors of the economy redundant.

A comprehensive overview of the methods and algorithms for simulating ceramic materials using computer graphics and CAD, as well as their limitations, challenges, and application-specific requirements was presented. It proposed a future research direction on developing new or improved methods and algorithms that can address these issues and achieve better simulation results. It also discussed the potential benefits of this research for advancing the ceramic industries and improving the design and manufacturing of ceramic products. Finally, it expressed its hope and motivation to inspire other researchers to join this exciting and important research field.

The social and ethical implications of computer graphics and CAD for ceramic industries were evaluated. It reviews the literature, identifies the stakeholders and values, proposes a framework or method, and applies it to some case studies or scenarios. It finds that computer graphics and CAD are powerful and promising technologies, but they also pose some social and ethical issues. It provides some recommendations to help the researchers, practitioners, regulators, and consumers of these technologies to make informed and responsible decisions. It also acknowledges the limitations and challenges of its research and suggests some directions for future research. It hopes to contribute to the field and raise awareness and discussion among the users of these technologies. It urges them to consider the implications and use them wisely and ethically.

References

Auxier, B., Rainie, L., Anderson, M., Perrin, A., Kumar, M. and Turner, E. (2019) Americans and privacy: Concerned, confused and feeling a lack of control over their personal information. Pew Research Centre. Retrieved from https://www.pewresearch.org/internet/2019/11/15/americans-and-privacy-concerned-confused-and-feeling-lack-of-control-over-their-personal-information/ on May 10, 2023.

Badu-Nyarko, S.K. (2012) The impact of computer technology on the development of children in Ghana. International Journal of Education and Development using Information and Communication Technology, 8(1): 91-103.

Berman, B. (2012) 3-D printing: the new industrial revolution. Business Horizons, 55(2):155-162.

Bose, S, Vahabzadeh, S. and Bandyopadhyay, A. (2013) Bone tissue engineering using 3D printing. Materials Today, 16(12):496–504.

Butler, J. E. (1996) Theories of technological innovation as useful tools for corporate strategy. Strategic Management Journal, 7(1):15-29.

Copeland, B.J. (2023) Artificial intelligence (AI). Britannica. Retrieved from https://www. britannica. com /technology /artificial-intelligence. Accessed August 17, 2023.

He, Y. (2022) Research on innovative thinking of ceramic art design based on artificial intelligence. Mobile Information Systems, 2022, 3381042.

Hurt, D. (1996) Computers and people with disabilities: A new partnership. Journal of Information Systems Education, 8(2):11-16.

Kaczmarczyk, L.C. (2012) Computers and society: Computing for good. CRC Press.

Negroponte, N. (1995) Being digital: The future of information and communication technology New York, NY: Alfred A. Knopf, p11-12.

O'Callaghan, J. (2020) Here's how technology has changed the world since 2000. World Economic Forum. Retrieved from https://www.weforum. org/agenda/2020/11/heres-how-technology-has-changed-and-changed-us-over-the-past-20-years. on May 22, 2023

Orkas, J., Ranta-Eskola, A. and Salmi-Tolonen, T. (1987) Computer-aided design for ceramics. Computers & Graphics, 11(2):145-150.

Riihimäki, J. and Tuomi, J. (2005) The impact of 3D CAD on product development process. International Journal of Product Development (IJPD), 2(1-2):77-94.

Scott, R.A. (1969) The making of blind men: A study of adult socialization. Russell Sage Foundation. p.3.

Sichel, D.E. (1997) The computer revolution: An economic perspective. Brookings Institution Press.

Sorkine, O., Lipman, Y., Cohen-Or, D., Alexa, M., Rössl, C. and Seidel, H.P. (2004) A sketch-based

interface for detail-preserving mesh editing. ACM Transactions on Graphics (TOG), 23(3):1149-1156.

Westin, A.F. (1970) Privacy and freedom. 1st ed. Atheneum.

Wong, K.V, Hernandez, A. (2012) A review of additive manufacturing. ISRN Mechanical Engineering, 2012:1–10.

Zhang, D., Liu, X., Qiu, J. (2021) 3D printing of glass by additive manufacturing techniques: a review. Frontiers of Optoelectronics, 14(2):263-277.