Patent Documents: Facilitating Visually Impaired People in Mathematical Education Through Innovative Solutions

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Abstract: A patent is a legal protection which gives an inventor the right to exclude others from performing a certain activity in the country of issuance. Innovations in form of patents are very beneficial for societies i.e., economic growth, reducing unemployment, increasing motivation and enhancing educational support. Visually impaired people are also part of society who faced several difficulties during access to educational material. Continual enrichment in technology has yielded a lot of innovative solutions for visually impaired people which have been patented. These solutions are in form of published articles, systems, applications and websites. Researchers can access journals, conferences, book chapters and technical reports easily but normally patents are unused sources of information in education. The main reason behind this is the complex structure of the patents which causes difficulty in reading. The proposed article aims to summarize the patent information in such a way that researchers and developers can easily access the information. Discuss some important patent offices from all over the world, along with their patent tools. A detailed analysis was conducted for patent documents that are of help to visually-impaired people learning mathematics.

Keywords: Patent, Intellectual property, Education, Visually impaired, Mathematics

Introduction

Nowadays, several innovative solutions were proposed by researchers to increase the knowledge of humans. There is always a need to protect these creative and innovative solutions, ideas and designs from copying without the permission of the real owners. Intellectual Property Rights (IPR) play an important role to protect these ideas. Patents, copyrights, trademarks, trade secrets and design are described as a form of IPR. Patents provide proper rights to the creator and inventor for a specific time duration to detect infringement of intellectual property [1]. Patents are important research resources and are quite useful in educational programs to enhance the knowledge and professional skills of students. These are also very helpful in introducing innovative solutions to change state-of-the-art technologies [2].

Visually impaired peoples are an important part of society. Government institutes always try to facilitate them and overcome their daily routine challenges [3]. In the field of education, mathematics is a very important subject and visually impaired students use their hearing and touch senses in absence of vision in their learning [4-5]. But still, they faced many challenges in accessing mathematics material and concepts [6]. Researchers and developers from all over the world exploring innovative solutions for their rehabilitation. They normally use human-computer interaction-based techniques to introduce assistive solutions. Assistive technology is very useful for visually impaired people in enhancing their quality of life. Technological improvements in tactile interfaces, wearable solutions, auditory feedback, smartphone and web-based solutions provide new opportunities for visually impaired people [7]. Smartphone-based solutions are easily accessible for visually impaired people and are used to enhance their interaction with the content [8]. Visually impaired people can easily enter the text [9], and perform gesture-based [10] and multi-touch interaction [11] with mobile applications.

Patents have rich technical information for researchers and developers that is not published in important scientific platforms i.e., symposiums, conferences and journals. So, searching the relevant patents are also a difficult task. In this article, we are going to discuss important patent databases and the searching mechanism of patents by using automated tools. Patent2Net (P2N) is an open-source and lens.org web-based patent analysis tool. We have examined several important features of patents that were directly associated with the mathematical education of visually impaired people.

The remaining paper is organized as section II for a brief discussion on related work of previously designed assistive solutions for visually impaired people. Section III is named as the patent documents: a quality source of information that describes the important patent offices in the world, the life-cycle of patent documents and different types of Patent users. Section IV illustrates the importance of patents in mathematics education of the visually impaired. Section V provides a brief conclusion of the selected topic.

Related Work

Nowadays innovative technologies changed visual impaired people's daily lives. They can perform their daily routine tasks easily i.e., communicating with their friends, easily accessing information and enhancing their learning skills. Earlier research showed that the focus was shifted in visually impaired people from vision to hearing in eye free environment because their hearing power is more than normal people [12-13]. Due to the inception of advanced technology in recent years, many human problems cured and new innovative applications have been proposed by researchers to handle different problems effectively (accessing mathematics material is one of them). They can solve a mathematical problem on a computer system. The Universal Mathematics Accessibility (UMA) system [14] was developed with the association of multi-institutes. Its purpose is to make mathematics accessible globally. UMA has a translator that converts documents in such kinds of formats that are easily accessible for visually impaired people. With the help of FreeTTS and Java, Speech API oral navigation performs without any difficulty. Auditory interfaces improve the process of retrieving information from non-visual interfaces in blind people.

It is very difficult for visually impaired people to know about science concepts. Different activities plan in different places to observe how blind people can act when they interact with other people and understand the situations accordingly. The results were diverse because due to alternate places their nature affected them differently. For a decade software-based solutions help to encourage them to learn more attractively. Blind people can use software happily because most of them feel pleasure during the use of mobile devices. Different audio base virtual environments are also helpful for blind people to learn, develop and improve their skills. Audio Nature [15] is software, that worked on mobile devices for learning for the visually impaired. The interface models in software were represented through audio to an adjacent location because it's easy for users to interact with them. The interaction of the blind user with AudioNature makes through mobile touch screens and buttons. When they interact, audio feedback was generated that helps to realize the effect of actions and the state of the ecosystem. During the evaluation, highly satisfactory results were obtained which help to improve problems solving skills. It also helps to modify and improve the design of the software. Interactive interference assists blind people in a way to set their mental model according to the situation.

Several visually impaired users can use smartphones in their everyday tasks and new research has been done to make new hardware for phones that are specially designed for people having low vision. New development in the field of Vibrotactile, Text to Speech (TTS) and gestural recognition system makes them more accessible for a person with visual impairment. Human-Computer Interaction based research also supports the eyes-free method for the visually impaired. Foogue [16] is an eyes-free interface that allows the user to use gestures and audio to access information. A user who wants to play or access the next file will use hand gestures by holding a phone or he can also use the haptic or audio combination to make a command. Audio browser [17] also provides a technique that accesses information by speech and non-speech audio feedback. The user is guided by audio or non-audio feedback as the user touches the screen and accesses information. As mobile technology is going popular day by day, researchers are eager to make more and more efficient, less expensive and functional handheld mobile devices. In addition to more generalized innovation in the field of mobile devices researchers have also explored the prospect of braille display as a touch-based interaction for visual impairment. The simplest such approach is brailleTap [18].

The Patent Documents: A Quality Source of Information
Important Patent Offices in World

There are many important patent offices all over the world some of them are listed in Table 1 named as WIPO, USPTO, EPO, JPO, CNIPA and IPOI. Almost every office has an independent database for patent search. Also, there are several tools are available for analysing the information of the patents i.e., AppFT, PAIR and Espacenet.

Table 1. List of Important Patent Organizations and their Databases for Patents

Sr No	Patent Organizations	Website	Patent Databases/tools
1	World Intellectual Property Organization (WIPO): It is a self-funded forum to protect Intellectual Property (IP) i.e., patent, copyright, trademark and designs	https://www.wipo.int/pct/en/	1. PATENTSCOPE
2	The United States Patent and Trademark Office (USPTO): It helps in the technological and industrial progress of the nations and offered patents since 1790.	https://www.uspto.gov/patents	1. AppFT (Patent Applications) 2. Global Patent Search Network (GPSN) 3. Patent Application Information Retrieval (PAIR)
3	European Patent Office (EPO): Patent applicants can submit their request for protection in EPO. It provides bibliographic data from 70 different countries.	https://www.epo.org/searching-for-patents.html	1. Espacenet 2. Global Patent Index (GPI)
4	Japan Patent Office (JPO): It specifically contains Japanese patent information. The National Center for Industrial Property Information and Training (INPIT) collect and store industrial information and provide requested information during searching.	https://www.jpo.go.jp/e/system/patent/gaiyo/patent.html	1. J-PlatPat by INPIT
5	China National Intellectual Property Administration (CNIPA): It provides support to 94 patent institutes from the People's Republic of China to publish full-text patents.	https://english.cnipa.gov.cn/col/col1329/index.html	1. PSS-System (Patent Search and Analysis System)
6	The Intellectual Property Office of Ireland (IPOI): The IP office of Ireland is responsible to register the IP rights i.e., patents	https://www.ipoi.gov.ie/en/types-of-ip/patents/	1. Various tools available to access Irish patents

Life-cycle of a Patents Documents

A patent is a structured document that has to pass through several phases as mentioned in Figure 1 i.e., application submission, appose, appeal, published, granted, expired and withdrawal. At every step, many experts are involved in the evaluation of the quality, structure and metadata of patents. Each part of the patent has a different set of information i.e, the title provides the information of classification, the abstract express the information about inventions and the background states the problem considered for the solution.
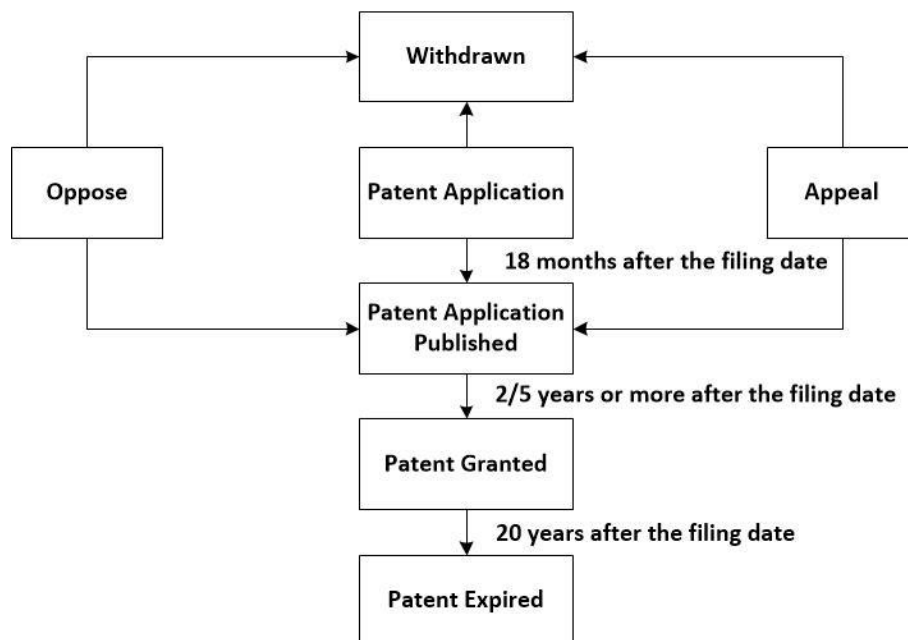

Figure 1. Visual Representation of a Patent Life Cycle

Different Types of Patent Users

Patents are quite effective to solve several technical issues in the educational sector. Patent information is very useful for many organizations, institutes and professionals (i.e., developers, researchers, patent examiners, patent lawyers and business analysts). Academic researchers and developers required detailed knowledge about any topic including its theoretical, practical and technical aspects. A patent provides them with a better chance to explore in-depth knowledge and enhance their understanding to tackle a similar problem [19]. So on, people from different organizations and companies like business analysts and managers would like to get information about the latest patents in their domain to introduce the new innovative solution for respective institutes [20]. This could be very useful for the business development of any organization.

Importance Of Patents In Mathematics Education Of Visually Impaired

This article promotes a unique idea to use patent information in the education of visually impaired students, especially in mathematics. Patent data is a very useful source of information for researchers and developers to introduce innovative solutions in pedagogic techniques of mathematics.

Patent Search Query

We have designed a search string to explore the patent database which covers the mathematical education for visually impaired people. Two operators represent the main structure of our searching, OR operator is used for the joining of similar and synonyms, where AND operator is used for the joining of major terms. Following keywords were part of the search strategy: ("Education" OR "Learning" OR "Remote learning" OR "Teaching" OR " Distance Education" OR "Classroom instruction" OR " Face-to-Face education" OR "Training" OR "Online Courses") AND ("Mathematics" OR "Graphs" OR "Calculus" OR "Algebra" OR "Statics" OR "Number Systems" OR "Equation" OR "Formulas") AND ("Smartphone-based solutions" OR "Web-based solutions" OR "Virtual Reality-based solutions" OR "Machine Learning-based solutions" OR "Desktop-based solutions") AND ("Auditory feedback" OR "Spearcons" OR "Tactile feedback" OR "Vibro feedback" OR "Braile" OR "Zooming" OR "Large Icons") AND ("Blind" OR "Visually Impaired" OR "Visually Impaired Students" OR "Visually Impaired People" OR "Vision Impairment" OR "Vision Loss")

Patent Documents Analysis for Learning Mathematics

We have used the lens tool to understand the several functionalities for patent analysis. You can open the website (https://www.lens.org/) the access the lens tools by clicking on Patents, Scholarly Works, API&Data, PatSeq and PatCite. By clicking on the Patents tool a new window will appear which has several options i.e, the last update of the patent data set, all patents and filter options. After applying the search query to the patent database total of 5279 patents were retrieved. Patent analysis is mainly based upon patent documents over time, patent documents by published; filed and granted date, patent documents by legal status and categorization of top inventors. Figure 2 provides a detailed analysis of the number of patents over the years. The highest patent document count is in the year 2021 with 637 patent documents. From 1978 to 1985 and 1987 have no patent document.
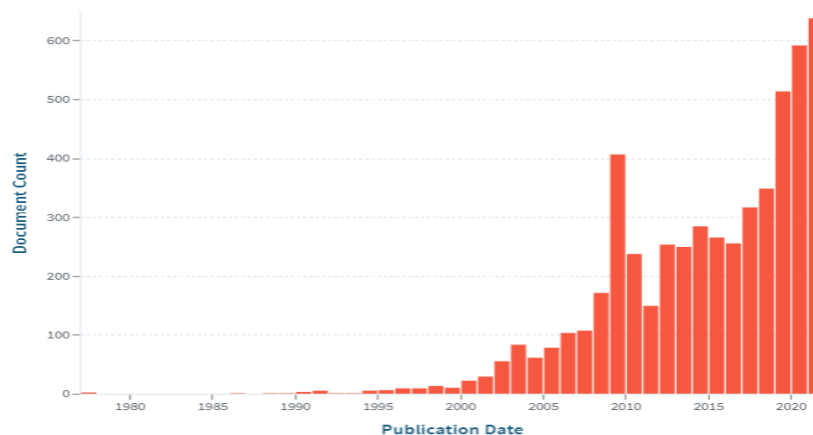

Figure 2. Patent Documents over Time

Figure 3 showed the patent documents by Published, Filed and Granted Date. Blue color represents filled, orange shows granted and red express the published patent each year. The highest patents were filed in 2008 with a value of 552, the maximum published patent in 2021 with a value of 637 and the maximum patents were granted in 2020 with a value of 379.
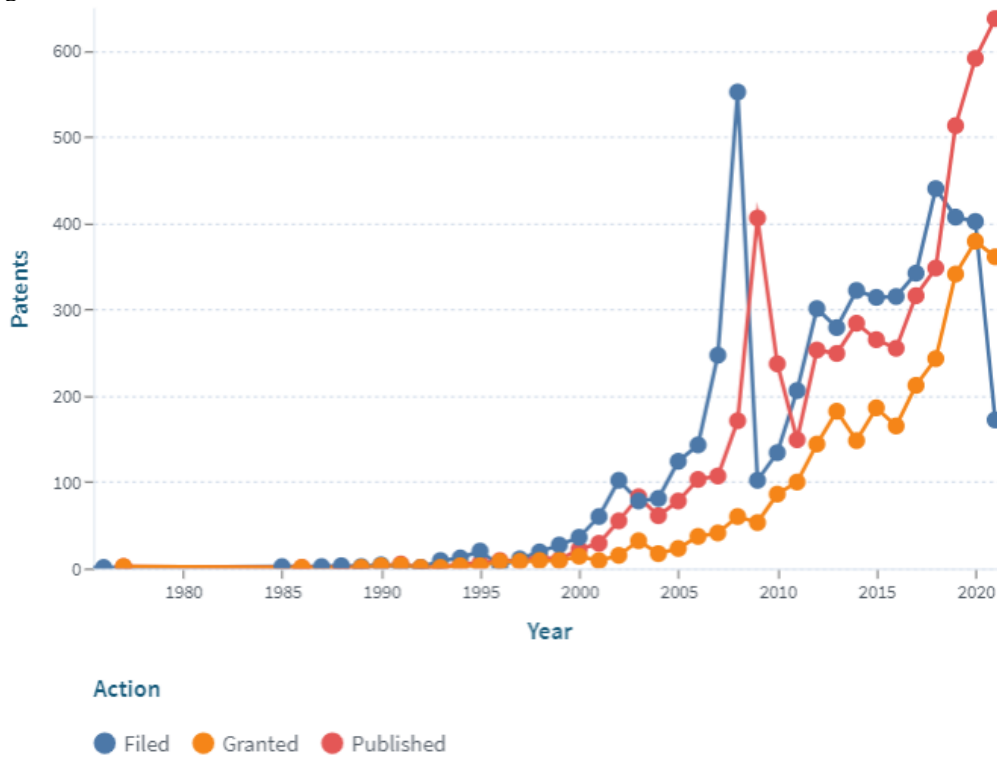

Figure 3. Patent Documents by Published, Filed and Granted Date

Figure 4 denotes patent documents by Legal Status, the x-axis represents document count and the y-axis shows the legal status of the patents. According to the current analysis 2365 patent documents are active, 1564 pending, 768 discontinued, 350 expired, 194 inactive, 29 unknown and 9 patent.
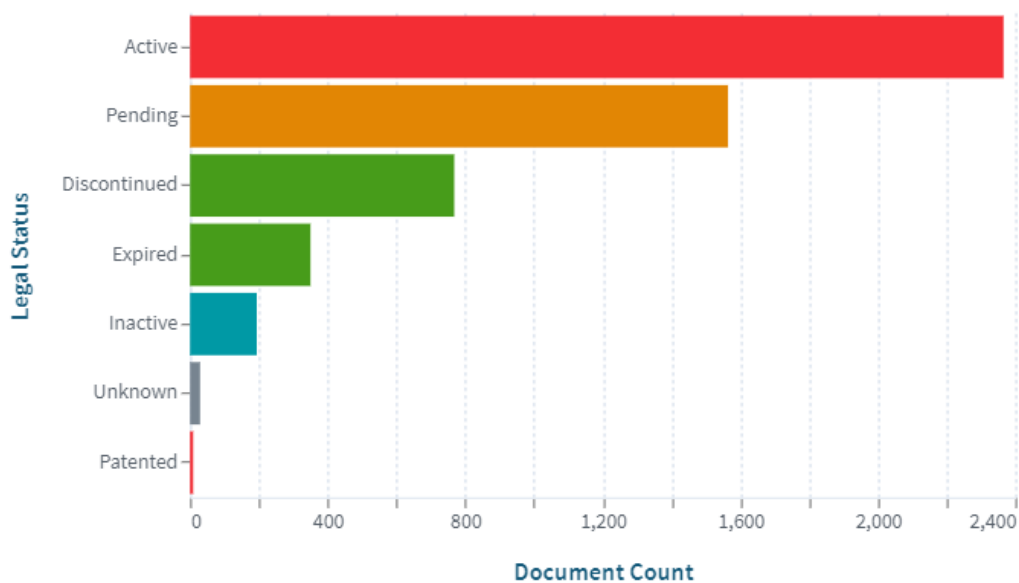

Figure 4. Patent Documents by Legal Status

Figure 5 provides the categorization of top inventors named Bevec Dorian, Bacher Gerald, Cavalli Fabio, Cavalli Vera, Bugenhangen Michel, Tran Bao, Morrill Robert, Deciu Cosmin, Wiley William and Osterhout

Ralph. The Bevec Dorian has the highest patents with a value of 426 and Osterhout Ralph has the lowest patents with a value of 67.
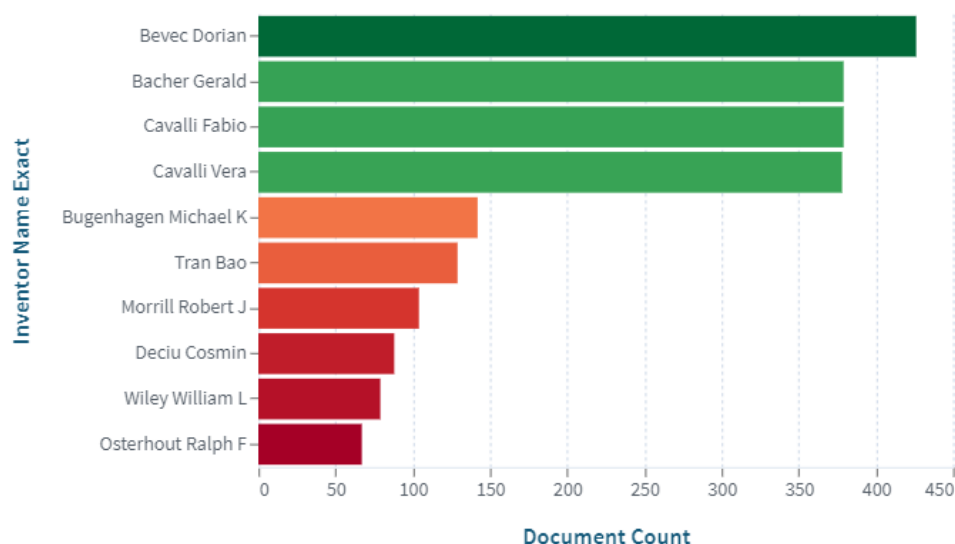

Figure 5. Categorization of Top Inventors

Conclusion

This article contributes by discussing some world-famous patent offices WIPO, USPTO, EPO, JPO, CNIPA and IPOI along with the useful tools for analysing the patents. A visual representation of a patent life cycle is drawn and discussed the important phases of a patent ie., application submission, appose, appeal, published, granted, expired and withdrawal. Several patent users are also highlighted such as academic researchers, developers, patent examiners, patent lawyers, business analysts and company managers.

Additionally, summarize some patent information that provides educational support to visually impaired people. Millions of patents are freely available so, open-source tools are used to explore the worldwide databases of the patents. After searching and exploring provides the results in a graphical form that can easily be accessed by researchers. We also have discussed the patent information retrieval process by using the lens data mining tool to explore the freely available patent databases.

During the patent searching, a total of 5279 patents were retrieved that were useful for the mathematical education of visually impaired people. The search results were based upon the patent data which is not published in any other literature. A comprehensive search was conducted to find the yearly filed, published and granted patents. Also mentioned the legal status of the patents and listed the top inventors from the retrieved patents. The purpose behind this was to refine the patent search by using freely available tools and share the results with other communities of researchers. With the help of the open-source data processing tools results can be generated quickly and properly visualize the patents information to enable their implementation.

Notes

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