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Open Source Database and Website to Provide Free and Open Access to Inactive U.S. Patents in the Public Domain

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Abstract: Although theoretically the patent system is meant to bolster innovation, the current United States Patent and Trademark Office (USPTO) is cumbersome and involves a significant time investment to locate inactive patents less than 20 years old. This article reports on the development of an open source database to find these public domain ideas. First, a search strategy is explained. Then the operation and use of free and open source software are detailed to meet the needs of open hardware innovators. Finally, a case study is presented to demonstrate the utility of the approach with 3-D printing. The results showed how the Free Inactive Patent Search enables users to search using plain language text to find public domain concepts and then provides a hyperlinked list of ideas that takes users to the USPTO database for the patent for more information. All of the source code to operate the search and the website are open source themselves and provided in the public domain for free. In the case study on 3-D printing the time to identify public domain patents was cut by a factor of more than 1500. This tool has the potential for accelerating the development of open hardware technologies to create high value for the public.

Keywords: open source database; inactive U.S. patent; public domain; open hardware; patent; innovation

1. Introduction

The concepts of patents were initially written into the U.S. constitution to foster innovation, by enabling inventors to earn a return on investment for their efforts in creating new useful artifacts using a 20 year intellectual monopoly [1]. In exchange the nation benefited from access to the intellectual property after the 20 year time frame had ended. Since this time the rate of innovation has accelerated substantially [2]. Many authors now argue that patenting actually slows technological progress overall [3–15] and in specific disciplines (e.g., in nanotechnology) [16,17]. This has resulted in calls for patents to be significantly weakened [18].

One area that makes the case against patents particularly clear is the development of free and open source software (FOSS). FOSS is computer software that is available in source code (open source) form and that can be used, studied, copied, modified, and redistributed without restriction, or with restrictions that only ensure that further recipients have the same rights under which it was obtained (free or libre). FOSS development has been well-established to provide improved product innovation over proprietary techniques of technical development [19–24], Open source software has a number of other positive attributes including: open innovation and diversification [25–27],

cumulative innovation [28], organizational innovation [29], software development efficiency [30], avoiding redundant work [31], cost effectiveness [32], the quality of code [24], and more creativity [33].

Under similar rights, free and open source hardware (FOSH) provides the "code" for hardware including the bill of materials, schematics, instructions, computer aided designs (CAD), and other information needed to recreate a physical artifact. FOSH similarly leads to improved product innovation in a wide range of fields [30,34,35]. FOSH, however, is not a new concept as expired patents were the initial conceptualization of FOSH, which was originally written into the U.S. constitution.

Thus, to accelerate technical development a means is needed for inventors and FOSH developers to find intellectual property (IP) in the public domain. One method, already exists: to search for patents that have expired one can set a T-20 year period at the United States Patent and Trademark Office (USPTO) search page [36] or Google Patents [37]. However, in the U.S. patent system if maintenance fees (required at 3.5, 7.5, and 11.5 years for $1,600, $3,600, and $7,400, respectively) are not paid an issued patent goes into the public domain [38]. This is not a trivial release into the public domain as about 50% of all issued patents expire prematurely for failure to pay maintenance fees [39]. Currently, it is not readily available what patents are in the public domain and which ones are not. There is a way to see if maintenance fees have been paid, but it is not easy for users to access as the USPTO's PAIR website [40] demands looking up each patent individually, which is cumbersome. The challenge is how to integrate inactive patent numbers to their title and issue date, so that they would become openly available to everyone and users can search through them effortlessly using keywords. Instead of reinventing the wheel, the ability to find IP in the public domain of inventors and FOSH developers would help accelerate their ability to continue to develop more advanced technologies. This article reports on the development of an open source database to find these public domain ideas. First, a search strategy is explained. Then the operation and use of the software are detailed. Finally, a case study is presented to demonstrate the utility of the approach with 3-D printing. These results are presented and discussed.

2. Materials and Methods

2.1. Database

MySQL [41] is an open-source relational database management system (RDBMS) and widely used for web applications. Many open-source content management systems (CMS) use MySQL as their database, such as WordPress [42], Drupal [43], and Joomla [44] and many famous companies also use MySQL as their database, such as Google, Facebook, and Adobe [45]. MySQL was chosen as the database for this project because of its flexibility and ability to integrate with other potential partners. The structures of all tables are shown in Tables A1–A4 of Appendix A. It should be noted, that it is important to add the index to the specified fields to increase the performance of the search query time.

2.2. The Full Text Patent File Format

Since June 2013, the USPTO and Reed Tech have provided patent and trademark public bulk data available free of charge online [46]. Although there is considerable information about patents available on the website, the Patent Grant Red Book [47] provides weekly new granted patents from 1976 to present in full text and is used here. To build a functional public domain innovation database, patent number, title, and issue date of each granted patent must be extracted first. There are three file formats, as shown in Table 1, which must be processed based on the year the file format was in force. The file formats summarized in Table 1 include URL, which is an acronym for Uniform Resource Locator, TXT is a file extension for text files, which are structured as a sequence of lines of electronic text, SGML, which is an acronym for Standard Generalized Markup Language and XML, which is an acronym for Extensible Markup Language.

Table 1. The full text patent file formats and bash scripts.

Year	File Format	Bash Script	Input
1976–2000	TXT	Import-full-text-patent-txt.sh	URL
2001–2004	SGML (2001) and XML (2002–2004)	Import-full-text-patent-sgml.sh	URL
2005–Present	XML	Import-full-text-patent-xml.sh	URL

2.3. TXT File Processing

For the text file (1976–2000), the script (import-full-text-patent-txt.sh) starts with clearing the assigned working folder, then downloading a zip file from a given URL and unzipping the file. The unzipped file will be in the text file, which contains multiple granted patents and results in a large file size (200+ MB). Working directly with this large of a file (i.e., loading it into memory) decreases the performance of the server due to the availability of memory. In this large file each patent starts with the same code tag, 'PATN', so the script uses this tag to split the large file into multiple temporary files with five digits of running numbers. Each temporary file contains only information for one patent. Finally, the script loops into each file and reads the patent number, issue date, title, and term of grant, and then loads the data into a table named 'txt_full_text_us_patents'. The tag for the patent number is 'WKU'. There are nine digits of numbers following 'WKU' tag, where the first eight digits is the patent number and the last digit is the check digit. The tag for patent issue date is 'ISD'. The tag for patent title is 'TTL' and the tag for term of grant is 'TRM'. However, after loading the information, it was found that most of the patents do not have term of grant data. The script for text files is only for 1976 to 2000 data, thus, after running it for this year range there is no need to run it again.

2.4. SGML File Processing

Although the XML files (2002–2004) use the XML extension for the files like the files from 2005 to present, the tags used inside are the same as in the SGML files of 2001. Thus, the script for SGML (import-full-text-patent-sgml.sh) is used for the XML files from 2002 to 2004 as well as the 2001 data. The script starts by removing all the remaining files in the assigned working folder, then downloading a zip file from a given URL and unzipping it. After that, it splits the file into multiple temporary files by the tag '<PATDOC ... >'. Lastly, the script loops into each temporary file to read the data between the tags, <B110><DNUM><PDAT> and </PDAT></DNUM></B110> for patent number, <B140><DATE><PDAT> and </PDAT></DATE></B140> for issue date, <B540><STEXT><PDAT> and </PDAT></STEXT></B540> for title, and <B474><PDAT> and </PDAT></B474> for term of grant. All data are inserted into table named 'sgml_full_text_us_patents'.

2.5. XML File Processing

Finally, for the XML files (2005–present), the process of script (import-full-text-xml.sh) is similar to the above scripts. First, the assigned working folder is cleared, a zip file is downloaded from a given URL and unzipped, and split into multiple temporary XML files. It uses the '<xml>' pattern to separate the file. Next, it loops into each file and reads the data from each file and inserts the data into a table named 'full_text_us_patents'. The patent number is between the tag <doc-number> and </doc-number>. The issue date is between the tag <date> and </date>. There are multiple <doc-number> and <date> tags in a single temporary file, so the script needs to be specified to consider only the first of each tag (include q parameter in the 'sed' command, so the script would stop after finding the first match of the pattern). The title is between the tag <invention-title> and </invention-title>. The term of grant is between the tag <length-of-grant> and </length-of-grant>. The data from table 'txt_full_text_us_patents' and 'sgml_full_text_us_patents' would need to be inserted into table 'full_text_us_patents' in order to have all patent data from 1976 to present. This XML script will need to be run automatically in order to insert new patent data every week.

2.6. Patent Maintenance Fee Events Data Processing

The patent maintenance fee events data for patents granted since 1 September 1981 can be found on the Reed Tech USPTO Data Portal website [48]. It is a zip file that would be weekly updated (cumulative) on every Tuesday at 3:00 p.m. U.S. Eastern Time. As the URL link to this file is always the same, it is straight forward in the bash script to handle the file. After unzipping the file, a text file named MaintFeeEvents_yyyymmdd.txt will be found where yyyymmdd is the updated date (yyyy = year, mm = month, dd = date) of the text file. Each row or record in the text file contains U.S. Patent Number, U.S. Application Number, Small Entity, U.S. Application Filing Date, U.S. Grant Issue Date, Maintenance Fee Event Entry Date, and Maintenance Fee Event Code. Each column is separated by a space. From this text file, the column U.S. Patent Number and Maintenance Fee Event Code will be used to retrieve the expired patent numbers for failure to pay maintenance fee by checking the Maintenance Fee Event Code equal to 'EXP' (notice that there is a period at the end of the code).

A bash script (import-maintenance-fee-event.sh) was written to automate all the processes involved in the patent maintenance fee events data. The script starts with clearing previous files (MaintFeeEvents.zip and MaintFeeEvents_yyyymmdd.txt) if they exist in an assigned temporary working folder. Then the script would download the current MaintFeeEvent.zip from the website and unzip it. Because the text file is already in the format that can be easily loaded into a database, the script loads all the data into a table named 'maintenance_fee_events'. After that, the script would load only the patent numbers that have the Maintenance Fee Event Code equal to 'EXP' into table named 'expired_patents_checked'. Lastly, the script would map the expired patent numbers to their titles and granted issue dates from the table 'full_text_us_patents' and load them into a table named 'us_inactive_patents'.

2.7. Automatically Update Weekly

In order to update new granted and expired patent data every week on Wednesday starting at 1 a.m. U.S. Eastern Time, a bash script called 'autorun-everything.sh' is developed to do so. The script starts by making the website unavailable and showing the under maintenance page. Then it runs the script 'import-full-text-patent-xml.sh' to insert new granted patents into the public domain database. After that, the script 'import-maintenance-fee-event.sh' is run to update the expired patent numbers and map the data into the table 'us_inactive_patents' for the website to search in the title field according to given keywords.

2.8. Website Implementation

The website is developed using PHP for the back-end. For the front-end, the free Bootstrap template called 'Closet' from http://freehtml5.co was used in order to support different sizes of screens, PCs, and mobile devices. The usage of public domain patent website is the same as using the popular Google search website. The user types in words to search for patents that have entered into the public domain due to failure to pay maintenance fees. Then the public domain patent website will list titles, patent numbers, and issue dates of related patents to those keywords. The listing titles are hyperlinks to the full details of each patent on the USPTO website. The back-end process after receiving keywords from the front-end is to search in all inactive patents' titles with all the keywords that AND together would be created. Next, the connection to the MySQL database would be established and the query would be executed. After the search results return, the result would be arranged into groups of 25 for displaying as one page of results. At the bottom of the search result page, the user can navigate to the desired page of results. As a user looks into each record of results, if the user finds an interesting public domain patent, the user can click on the title, which would open up another web browser tab with the details of the patent hosted on the USPTO website. To search for new keywords, the user can click on 'Search' link at the top of the page to start the process again.

All source code for database and website can be found at https://github.com/mtu-most/patent-database.

2.9. The Current Approach

The current website of the USPTO allows users to search for patents relating to the topics that the user is interested in [36], or the user can also perform the search on Google's patent database [37]. On the USPTO website, users have to take some time to learn the syntax that is used for searching specific fields. For example, if a user would like to search in the title field, then the user has to specify that in the search box then follow the necessary indicator with a slash and keywords (e.g., ttl/(3d and printing)). After a user who is interested in innovating in open source space finds an interesting patent and would like to determine if the patent is in the public domain on not, the user needs to go to another page to check that information [49,50]. At this page, the user would need the patent number and application number of the patent to search on the page, and then would look for the information that specifies if the patent is expired. This is considerably more tedious than the user experience provided by the website developed here (http://freeip.mtu.edu) that requires the user only to type in the keywords, then have the results listed with all the related patents to the keywords in the public domain. The user knows all of the patents are free to derive innovations from without the risk of IP infringement and can click on the blue title hyperlink to see the details of the patent on the USPTO website. The usage of the freeip.mtu.edu website is similar to all search engine websites, such as Google, Bing, and Yahoo. It is obvious that this approach is much more user friendly and effective. However, to quantify this, a case study on 3-D printing is presented, which entails a time test between the current USPTO approach and the novel one described above. 3-D printing was selected for the case study because: (1) it is a technological area experiencing rapid growth both in terms of innovation as well as economic impact [51]; (2) it has an established track record of benefiting from open source technological development [52–54]; and (3) it has the ability to accelerate innovation in other fields [55] (e.g., it can be used for rapid prototyping, distributed manufacturing, and production [56–59]).

2.10. An Alternative Option

The alternative option for gathering information of patents is doing what is called "web scraping" or "web data extraction" from USPTO's or Google's patent search website. This option would cause a lot of traffic on both source and destination servers due to the fact that it has to be done patent by patent. Moreover, the content structure of the source needs to be identified, which is difficult in both the USPTO's and Google's patent search websites. The USPTO does not provide an application program interface (API) for patent search. The Google Patent Search API has been officially deprecated as of 26 May 2011, which makes it challenging to do web scraping.

3. Results

The successful embodiment of the concepts outlined above created a website located at http://freeip.mtu.edu. The website supports all screen sizes, PCs, or mobile devices. When a user goes to the website, the user can start typing keywords that he or she would like to search for right away because the input text box is automatically focused at the time of loading, as can be seen in Figure 1 for both a computer and a mobile device. Users can then press the enter button on the keyboard to start searching. As Internet usage through mobile devices has exceeded PC use in 2014 [60], mobile devices have become more and more important recently. However, the USPTO's patent and maintenance fee search pages do not optimize the support of mobile devices as would be expected in a modern website. The text displayed on the USPTO website appears quite small on a mobile device such that a user is likely to need to zoom in before being able to type anything. The Free Inactive Patent Search website supports all sizes of screen, so users can use either a PC or mobile device to access the site.

When the website is loading the results, the loading image shown in Figure 2 is used.

The search result would be listed in seconds. If there are more than 25 records, then the result is arranged into pages with 25 records on each page. Each result includes patent title, patent number, and its issue date, as seen in Figure 3. There is page navigation at the bottom of the page with many results.

When the user has found an interesting patent, the user can click on the blue title which is the hyperlink to the details of the patent on the USPTO website.

Figure 4 illustrates the current approach using the USPTO website compared to the approach given here to determine the status of a patent in the public domain.
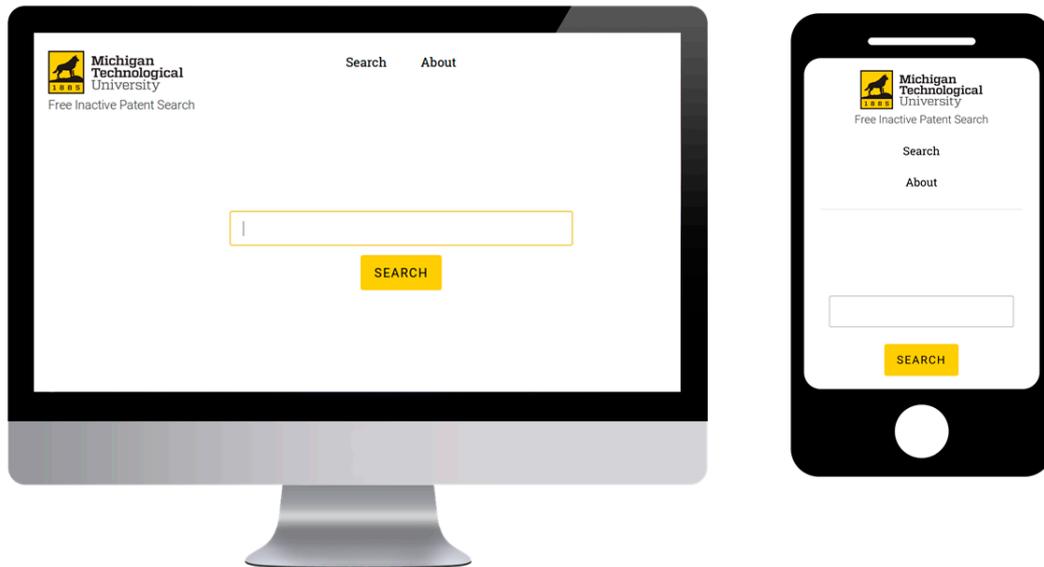

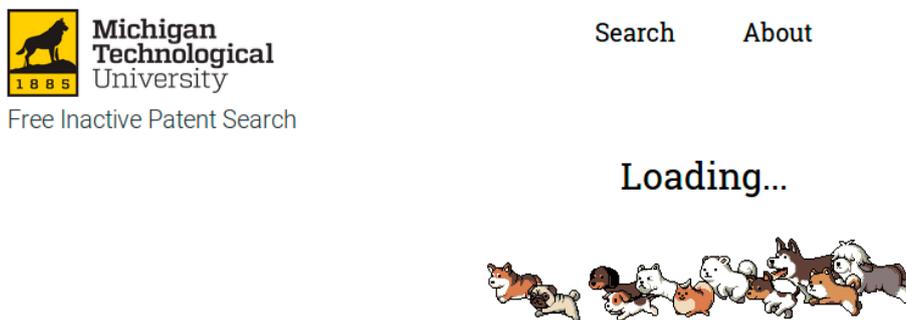**Figure 1.** The Free Inactive Patent Search Page displayed on a PC and mobile device.

Figure 2. Loading page.

About 31 results for "metal printing"

Lithographic printing with printing members including an oleophilic metal and plasma polymer layers
Patent No.: 7351517   Issue Date: 20080401

Roll for metal rolling, and support for lithographic printing plate
Patent No.: 7296517   Issue Date: 20071120

Magenta metal complex azo compounds and inks and their use in ink-jet printing
Patent No.: 7150782   Issue Date: 20061219

Magenta metal complex azo compounds and inks and their use in ink-jet printing
Patent No.: 7147697   Issue Date: 20061212

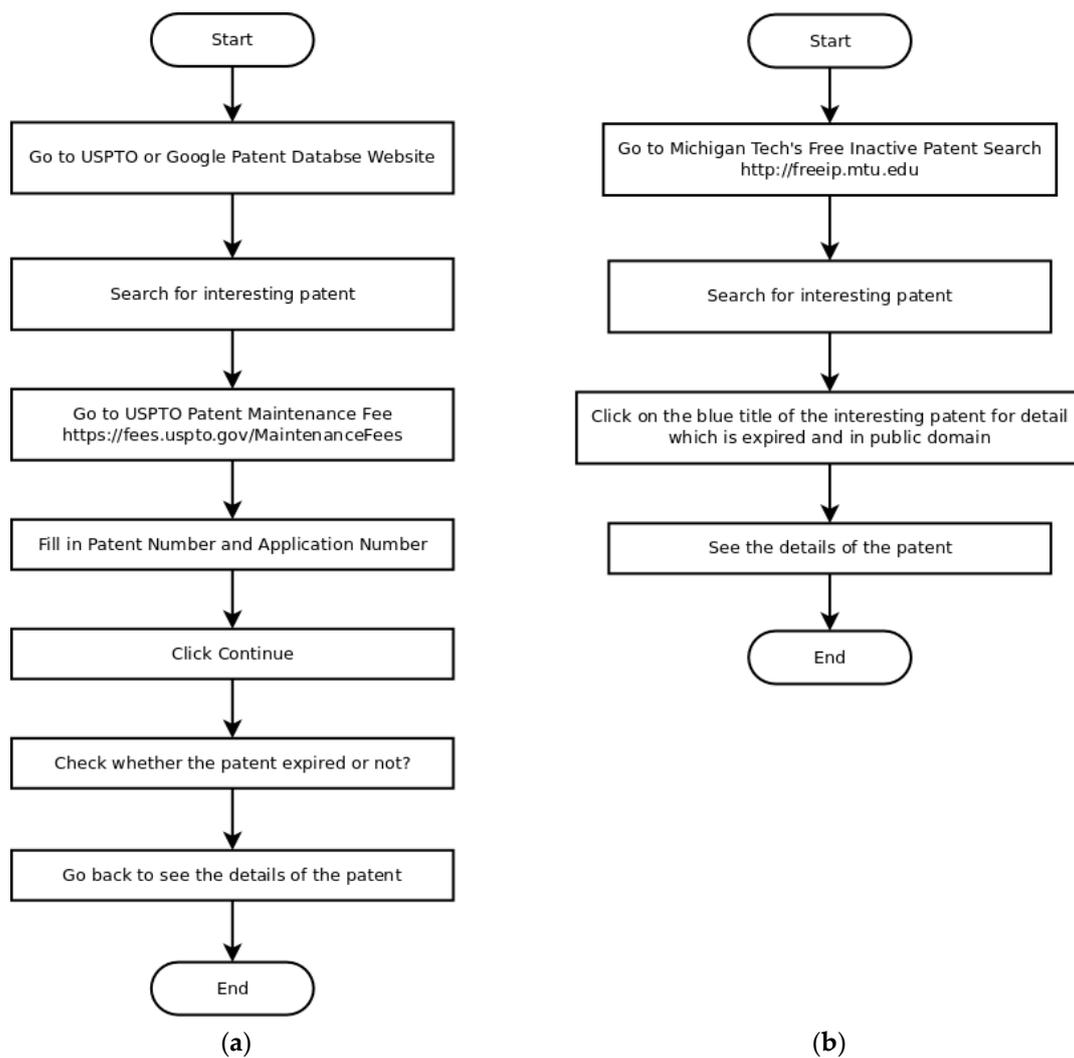**Figure 3.** Search results listed.

Figure 4. Search approaches for the USPTO Public PAIR (Patent Application Information Retrieval) vs. Michigan Tech's Free Inactive Patent Search: (**a**) Public PAIR approach; (**b**) Free Inactive Patent Search approach.

Free Inactive Patent Search enables users to search using plain language text to find public domain concepts and then provides a hyperlinked list of ideas that takes users to the USPTO database for the patent for more information. This tool has the potential for accelerating the development of open hardware technologies. To illustrate the potential of this website, consider the following case study of a user trying to identify inactive patents.

When a user goes to Google's patents search website and search for "3d printing" and selects for the U.S. only, there would be about 910 patents listed in the results for the last 20 years. Then the user must open another page (https://fees.uspto.gov/MaintenanceFees) to check whether the patents are expired or not. For example, the user clicks on the first record of the results page to see the details, 'Structural integrity when 3D-printing objects', the user would then go to the maintenance fee page and fill in the patent number (9,361,553) and application number (14/669,851) and click continue. Finally, the user would find out that the patent is not in the public domain. It would take about 35 s for each patent if the user was working quickly. In total, a user would have to spend 31,850 s or almost 9 h to find out that only two out of 4410 patents are in the public domain. On the other hand, if a user goes to Michigan Tech's Free Inactive Patent Search website and types in the same keywords, in 20 s the user would find out that there are two patents available in the public domain. This is over 1500 times

faster and would save the user more than 9 h in this particular case. This result is only provided to be illustrative of the potential time savings. If the search result of different keywords from Google's patents website shows a bigger number of results, then Michigan Tech's Free Inactive Patent Search website would save the user even more time. Similarly, for less actively patented technologies the time savings would be reduced.

4. Discussion

It is clear from the case study that the current website for the USPTO is not designed to optimize the search time for users to find public domain knowledge. This website is also not set up to help users navigate it in the way they prefer (e.g., on mobile devices). Both of these attributes are counter to the original mission of the patent office—to drive innovation. With the Free Inactive Patent Search code and website disclosed here it is now possible to use a selection of the U.S. patent database as a database of public domain knowledge. This database can thus be used as a foundation of a public domain knowledge base that the open hardware community can utilize to drive innovation faster than the proprietary system, thereby creating an enormous value [61] and return on investment [62].

To provide evidence of this potential, the rise of desktop 3-D printing will be used as an example. Although 3-D printing has only recently become an issue of public interest, the technology itself is old, having been patented decades ago. Unfortunately, patents restricted development of the technology to a few companies, whose lowest-cost option ($20,000 for fused filament fabrication (FFF) under the trademarked FDM (fused deposition modeling)) made 3-D printing technology available to only a few corporations [52]. Now that those patents have expired and FFF 3-D printing with the RepRap (self-replicating rapid prototyper 3-D printers [53,54]) has created enormous growth in the desktop distributed manufacturing [58,59,63] and rapid prototyping sector [51]. This occurred primarily because FFF 3-D printers can be built for only $500 from parts or purchased for around $2,000, thereby representing a 10x savings over older and inferior proprietary technology. In addition to the dozens of 3-D printing manufacturing companies that grew from this public domain knowledge, there is now a potential for hundreds/thousands of 3-D printing service companies [64], which could disrupt both manufacturing [65] as well as global value chains [66].

Finally, there is future work that would improve this website and database. An option to download all the search results as a file (e.g., in formats such as CSV (comma separated values), ODS (open document spreadsheet), XLS (excel spreadsheet), or an SQL (structured query language) table) could be added to the website, so when there are a lot of search results a user can keep track of them more easily. At the current stage, if a user would like to search for patents that are issued before 1976, the user can do that on Google patent search [37]. The patents before 1976 are available publicly in image files on the Reed Tech website [67]. To include those patents, open source optical character recognition (OCR) (e.g., https://github.com/tesseract-ocr) could be used to extract the text from each file or scrape data from a search-able database, such as Google's patent search patent by patent. In addition, many patents from the 1980s are also only available as image files, so the same procedure would be needed to include them. This work could be completed by the USPTO itself, Reed Tech, Google, or any other organization interested in accelerating innovation.

5. Conclusions

This paper successfully showed how the Free Inactive Patent Search enables users to search using plain language text to find public domain concepts and then be provided with a hyperlinked list of ideas that takes users to the USPTO database for the patent for more information. All of the source code to operate the search and the website are open source themselves and provided in the public domain for free. In considering a case study on 3-D printing, the time to identify public domain patents was 1500 times faster than using existing methods. This tool has the potential for accelerating the development of open hardware technologies in order to create a high value for the public.

Some technologies that were patented, but now are available in the public domain, might be abandoned because of the amount of time needed to search for them on websites. The Free Inactive Patent Search has the potential to accelerate the web search for those inactive patents and mitigates the problem.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. MySQL Database Script

Table A1. txt_Full_text_us_patents, sgml_full_text_us_patents, and full_text_us_patents.

Field Name	Data Type	Primary Key	Index
us_patent_number	varchar (8)	Yes	
us_patent_title	varchar (500)		Yes
us_patent_issue_date	int (11)		
us_term_of_grant	int (11)		

Table A2. us_inactive_patents.

Field Name	Data Type	Primary Key	Index
us_patent_number	varchar (7)	Yes	
us_patent_title	varchar (500)		Yes
us_patent_issue_date	int (11)		
us_term_of_grant	int (11)		

Table A3. maintenance_fee_events.

Field Name	Data Type	Primary Key	Index
us_patent_number	varchar (7)		
us_application_number	varchar (8)		
Small_entity	varchar (1)		
us_application_filing_date	int (11)		
us_grant_issue_date	int (11)		
maintenance_fee_event_entry_date	int (11)		
maintenance_fee_event_code	varchar (5)		

Table A4. expired_patenta_checked.

Field Name	Data Type	Primary Key	Index
us_patent_number	varchar (7)	Yes	

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