DESIDOC Journal of Library & Information Technology, Vol. 36, No. 2, March 2016, pp. 65-96 DOI: 10.14429/djlit.36.2.9504

Searching and Analysing Patent Document to Solve R&D Problems

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ABSTRACT

The task of analysing patent data using automated tools to dig out the desired information through visualisation, citation analysis, and other techniques are gaining importance. Patent information is presented and recorded in a very systematic manner which simplifies the task of searching relevant information for various purposes like technology forecasting. Patent documents help in drawing a baseline, identifying vacuums and then providing leads to fill these vacuums. The present paper is focused on finding patent documents as leads for an R&D problem, utilising various tools pertaining to patent literature including patent searching, text mining, and patent analysis to zero down the key patent documents as leads. A practical R&D problem related to the development of a drug delivery device for releasing the vapours of drug was imposed by scientists for which a systematic search was performed to extract most relevant patent documents using various patent analytical tools towards solving a practical R & D problem.

Keywords: Patent analysis, network model, search, keywords, drug delivery

1. INTRODUCTION

Technical information is growing at a very fast rate with continuous publication of huge number of articles, patents, reports, thesis, etc., and there are variety of information sources having different features and tools to access this publicly available information. Out of all the available storehouse of information, patent documents represent the most promising data in terms of being most structured, systematic, and updated. A patent document has abundant information about developed technology[1] which includes title, abstract, claims, inventors, and drawings, date of publication, and date of grant[2]. It is a techno-legal document which provides systematic disclosure of the invention and in return, the assignee/ inventor is granted 20 years of monopoly rights. Patents are the richest source of technical information which often can't be found anywhere else. As per a report from EPO, upto 80 % of current technical knowledge can only be found in patent documents[3]. Moreover, this information is available in public domain, as patent applications are published 18 months after the first filing, irrespective of their country of origin. Further, after the grant, a granted patent document is also published for the benefit of public[4]. The present paper is an endeavour to showcase the utility of patent documents in providing useful information/leads to solve R&D problems. The paper also describes in detail the techniques and steps to achieve the desirable results.

2. LITERATURE REVIEW

Patent documents represent a huge reservoir of information which is presented systematically and updated almost on weekly basis by patent offices of different countries[5,6]. Another important advantage of patent documents is that these could be searched with the help of logic gate operators on freely available databases as well as paid databases[7]. Patent search is the foremost step to start any R&D project for any regulated markets.[8] However, there could be different reasons of conducting a patent search which may include finding technology trend, building strategy for a project, infringement analysis, patent validity opinion, identifying niche segments in a technology, technology hotspots, finding collaborators/ inventors for joint development or finding suitable licensee, etc.[9-,11.] Depending upon the requirements, the entire orientation of the patent search is modified to reach at the desired goal. Among all these reasons, using patent information is to take a jump start in a project may sound fascinating to scientists who are always engrossed in their research work. Patent documents consist of most advanced technological information than any other form of literature[12]. However, searching patent literature is a skilled job where the use of appropriate keywords or classification or a combination of both may be required. Selection of keyword and classifications ultimately decides the quality of search report[13,14]. Another important aspect of patent search is the noise that remains very high in almost all searches[15].Several means and tools have been advised by the researchers to overcome the problem of noise in patent searches. Again, deducing the right information from this huge information is very tedious and tools like patent maps, citation analysis, co-word analysis, Bayseian models, network models, clustering coefficients, etc., have been suggested by

Received 9 November 2015, revised 17 January 2016, online published 28 March 2016

several researchers[16-18]. Various software are available to implement these analytical techniques, viz, Aureka from Thomson Reuter; IPMap Documents from Dolcera Patent Matrixs; and Spores Search Patents from Neopatents; Invengine™ Patents from Invengine; and like.

3. R&D PROBLEM

Scientists needed to develop a drug delivery device which can first actuate the release of drug from distant location and then release the drug in a predetermined manner. For this purpose, an appropriate delivery system is required so as to keep the drug dissolved in a suitable volatile vehicle, for ultimate release of the same as vapours. Further, the dose and release rate of drug vapours from delivery device has to be controlled and monitored thoroughly. Thus, to sum up, a drug delivery device which can first actuate the release of drug from distant location and then release the drug in a predetermined manner is required to solve this R&D problem. The problem may be summarised as 'providing leads for delivery system to deliver drugs'.

4. DATA COLLECTION AND ANALYSIS

For the present problem, Orbit™ a patent database from M/s Questel, has used for a thorough patent search which has several features that help in refining the search. Orbit™ is a platform specialised in patents which gathers information from more than 90 patent authorities worldwide and offers many unique modules, data, and functions (http://orbit.com/#WelcomePage)[19].

4.1 Keyword

Selection of judicious keywords affects the patent search significantly[20]. Brainstorming for the selection of appropriate keyword is very important and it is the key step in retrieving patent documents. If the keywords are not chosen properly, then results bring up too many or too few patents, therefore, an appropriate strategy for patent search for the present problem was prepared. In the present case, after discussion, keyword search was considered a relatively better option wherein all the features of the present problem could be searched. Following important features of the drug delivery system were identified:

- Delivery system should be able to initiate the release of drug from a distant location.
- Delivery system should be able to control the release rate of drug.

Based on these requirements, a search strategy was made and a comprehensive patent search was carried out. The essential feature of the present problem may be converted in a list of keywords as provided: (a) Drug; (b) Drug delivery; (c) Inhalation; (d) Remote; (e) Control

Once these features were identified, a matrix of keywords including synonyms, broad/generic words, and narrow words was developed, followed by the combinations of keywords (Table 1). All the possible combinations were made and searched on the Orbit™ which resulted in hits ranging from thousands to zero.

Table 1. Searched keywords and the hits

S. No.	Searched algorithm (searched part of patent document)	Results (No. of patent documents)
1.	INHALATION AND DEVICE (Desc)	204152
2.	A61K-009/22/IC (Classification Search)	8024
3.	delivery system AND remote (Desc)	1768
4.	inhalation AND delivery system (Desc)	1741
5.	inhalation AND delivery system(title;abstract;key content)	334
6.	drug delivery device AND remote(title;abstract;key content)	102
7.	drug delivery system AND remote (title;abstract;key content)	84
8.	drug delivery AND timer	51
9.	incapacitating AND A61K-009/22/IC	26
10.	INHALATION AND DELIVERY SYSTEM AND MASS	24
11.	drug delivery AND time control	8
12.	inhalation AND delivery system AND fentanyl	6

4.2 Data Screening

A preliminary observation was done for each result and the most relevant sets of patents were selected for the Level I screening.

Level I: Titles of inventions in patent documents form a useful secondary source of information, provided that they are reasonably informative. Titles of inventions impart first impression about the main content of the invention and appropriate sets of patent documents were selected based on the titles (http://www.wipo.int/export/sites/www/standards/en/pdf/03-15-01.pdf)[21]. The searched keyword combinations resulted in patent datasets having patent documents ranging from zero to lakhs. To scrutinise these datasets, titles were used and appropriate datasets were chosen for level II. Table 2 shows most relevant patent datasets and their keywords.

Level II: An abstract is a brief summary of the invention, and should include all of the important technical features of the invention. It is useful to both the Intellectual Property Office and to the public searching in the particular technical field of the application.[22] Abstracts are written in a way to make the invention easily understood by persons working in that area of technology. Therefore, selected sets of the patents were screened on the basis of abstracts. All the abstracts were downloaded and read to analyse the relevance of each abstract for the subject. Patent documents of high relevance were shortlisted and taken to level III.

Table 2. Most relevant patent datasets and their keyword

S. No.	Searched keyword combinations	Results
1.	Drug delivery + Inhalation+ fentanyl	6
2.	Delivery system + inhalation	334
3.	Drug delivery system+ remote	84
4.	Drug delivery device +remote	102
	Total	**526**

Level III: 68 shortlisted patent documents of level II were subjected to further patent analysis using patent maps and network analysis.

4.3 Data Analysis

A typical patent analysis scenario includes tasks of identification, searching, segmentation, abstracting, clustering, visualisation, and interpretation[23,24]. For the purposes of the present paper, patent analysis was performed using various tools.

4.3.1 Patent Maps

Patent maps of 68 shortlisted patent data were made. The shortlisted patents were placed as one set and various features were studied. Top assignees are found to provide a clue to the scientists for their work. Details of each assignee as required by the scientists was included. Patent maps of the patent documents were generated using the Global Patent Index tool with respect to date of publication, assignees and IPC classification. The two-dimensional trend patent maps of patent document with the year of priority/filing/publication on x scale and inventors/assignee name on y scale were generated using analytical tools (Figs 1-3). These maps provided a key insight of the technology. Figure 1 provides the time scale map of the international patent classification (IPC). As evident from the trend map, the patents in various fields have been filed over the years. However, the key focus area for this particular technology is defined by a set of classifications: A61M, A61B, A61K, and G01N. These set of IPC codes can be described[25] as: A61K-Preparations for Medical, Dental, or Toilet Purposes: A61M- Devices For Introducing Media Into, Or Onto, The Body; A61B-Diagnosis; Surgery; Identification; G01N-Investigating or analysing materials by determining their chemical or physical properties.This shows a considerable concentration of the technology in few selected areas as described by the IPC codes. Also the time scale shows, major filing in this area took place between the year 2000 and 2010.

4.3.2 Patent Network Analysis

Patent network analysis of the shortlisted patent documents was performed using UCINET 6.0. In the context of patent analysis, individual patents account for nodes and the relationships among patents represent edges in the network. The network analysis comprises several steps which include pre-processing the patent dataset to construct keyword vector for each patent and then formation of the matrix and finally generating patent network using the data of incidence matrix.

4.3.2.1 Keyword Vector

After the data collection, raw patent documents are transformed into structured data. Text mining that extracts keywords from patent document is used to determine the keyword vector. The process of keyword extraction includes identification of the keywords to be extracted from each patent document of the selected patent dataset. This removes the synonyms, generic name, prefixes, and suffixes from each selected keyword. Precise and accurate keywords are included followed by their frequency analysis in each patent. Finally, keyword vector is constructed. If a specific keyword is included in a patent document, then the corresponding keyword vector field is filled with frequency of occurrence. Likewise, in the present paper keywords vectors for the selected list of keyword were constructed and each patent document was presented in terms of keywords and the keyword vectors.

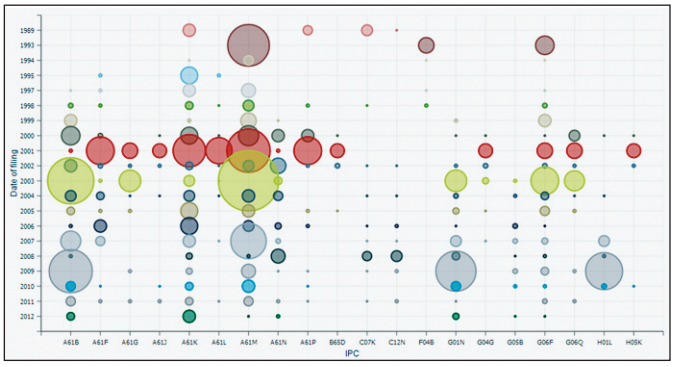

Figure 1. Technology trend map: Patent map showing date of filing vs IPC classification of the broadest patent dataset.

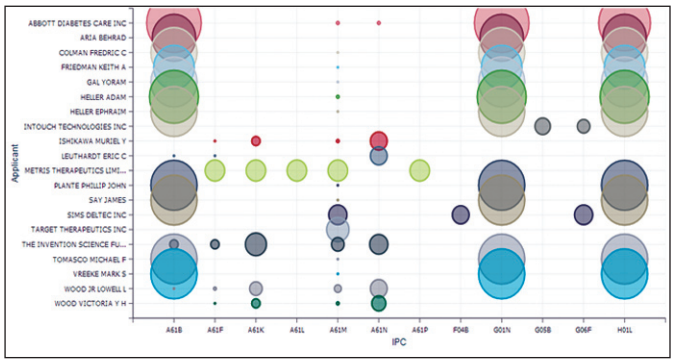

Figure 2. Patent map showing top 20 applicant vs date of filing.

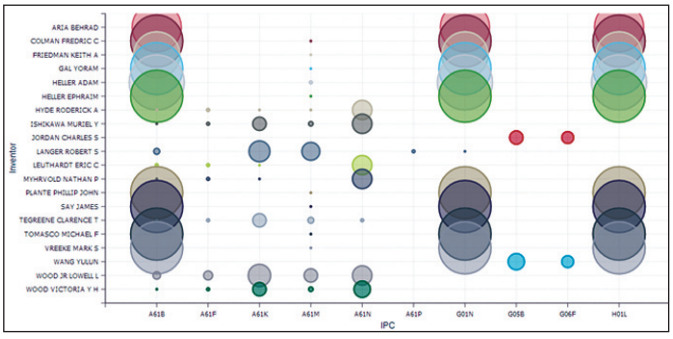

Figure 3. Patent map showing top 20 inventors vs IPC classification.

4.3.2.2 Construction of Matrix

The keyword vectors, keywords and the patent documents were used to build the matrix which is a prerequisite to generate a network model. Each patent document was quantified as keyword vectors which is the frequency of occurrence of a keyword in a patent document[26]. For a keyword "a", the keyword vector is "a1" and Keyword "b", the keyword vector is "b1" in patent number 1 then for the patent number 1, the keyword vectors are defined as (a1, b1, . . ., z1) and like-wise for the patent document 2, keyword vectors are (a2, b2, . . ., z2).

4.3.2.3 Generation of Patent Network

Once the matrix is developed, it is easy to develop network model by using various commercially available statistical tools. The input data is the matrix developed by subjecting the data to 1-mode affiliation using UCINET 6.0. In the present paper, UCINET 6.0 version was used for the generation of network model and graphs. The network models were generated using the 1 mode affiliation matrix. A well constructed network model provides a comprehensive outlay of the interconnection between all the node and edges. The interconnections between the edges and nodes in present research represent the patent documents and the keywords respectively. Further, the interconnection between these two factors is determined in term of the keyword vector. The matrix is more concentrated on few keywords which establish strong and dense correlation between patent documents and keywords. Network model for the broad set of patent documents comprising 68 patent documents is shown in Fig. 4.

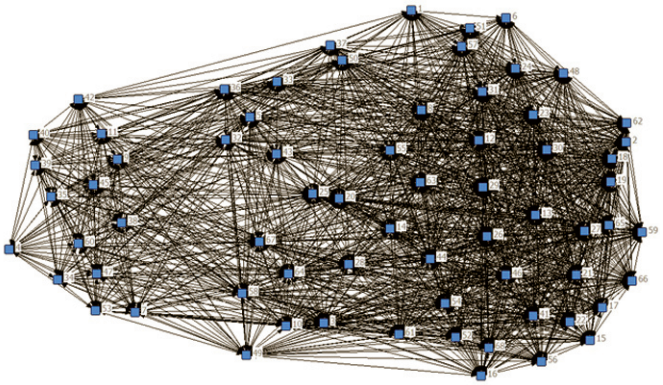

Figure 4. Patent network of relevant patent documents.

4.3.2.4 Quantitative Analysis of Patent Network

Patent analysis involves a series of steps, including extracting patents from patent databases, extracting the information from the patents, and analysing the extracted information to infer the logical conclusions. Keyword-based quantitative approaches to generate networks and then the quantification of the various network parameters help to deduce useful information about the complex patent documents. Overlapping the quantitative parameters with the graphical presentation of patent datasets is an extensively used methodology and it has been illustratively used in many research works[27]. Similarly, for the purposes of understanding the present R&D problem and among various tools to solve it, quantitative parameters of the network model were calculated using the calculus of UNICET 6.0 version.

4.3.2.5 Technology Centrality Index and Closeness Centrality Measures

In graph theory and network analysis, centrality refers to an indicator which provides intuitive values for finding the central focal point of a network. The centrality index, is the measure of the degree of centrality in network analysis, defined as:

$$C_D(n_i) = d(n_i)/g\text{-}1$$

where $d(n_i)$ is the number of lines that are incident with patent i and g is the total number of patents. The centrality index in patent network is interpreted as the ratio of the number of tied links to all g-1 other patents[28]. Therefore, the higher the centrality index, the greater the impact on other patents. The centrality indexes of patents with more than 0.5 value are presented in Table 3.

Table 3. Technology centrality indexes of some important patents

Patent number	Centrality measures
US5694919	0.857
US2011004188	0.667
US2008114299	0.750
US8002700	0.750
US6464687	0.667
US5928195	0.667

4.3.2.6 Density/Average Matrix Value

Another main indicators of a network model analysis are density and geodesic paths which are measured to understand the network structure more efficiently[29]. In the network analysis, density of a network is the total number of ties divided by the total number of possible ties. The density of a graph is defined as the number of links divided by the number of vertices in a complete graph with the same number of nodes. Density index of the present matrix resulted in a considerable higher values, i.e., 29.9 for the network model of Fig. 4. Such a high density or matrix value represents the higher degree of relevance among the patents with respect to the keyword. The shortlisted group of patents is also having high cohesiveness among each other. The patents of this group could be clustered as they belong to minimally varying technologies involved in the remote control operated drug delivery devices.

4.3.2.7 Geodesic Distance

The relationship between patents should be quantified in terms of either distance or similarity. Among various indexes, the common Geodesic distance is used in

this research. In mathematics, particularly, differential geometry, a geodesic is a generalisation of the notion of a "straight line" to "curved spaces".30 In simple word, Geodesic distance in a patent network analysis measures the distance between two nodes. The Geodesic distance values assume real numbers from 0.0 to 1.0. The degree of connectivity, whether strong or weak, is decided based on this value that the analyser is supposed to determine. That is, the connectivity between two node is considered strong if the value of geodesic distance is closer to 1 and if this value between two nodes is lesser, i.e., closer to 0, the connectivity is considered weak.

5. DISCUSSIONS

In the present research, the projected R&D problem was: 'A remote control operated drug delivery device which should be able to deliver the drug in a predetermined manner'

Defining the problem crisply is a very important aspect of patent searching. Meaningful keywords help to to capture most relevant patent database, as the broad keyword provide an overall information about a problem and at the same time narrow keywords help to confine patents to gather required information. In the present work, keywords were drawn which could explicitly define the problem and followed by extending the keyword to include the synonyms, prefixes, suffixes, broad as well as specific keywords, etc., were included to make a comprehensive list of keyword. In the subsequent step, to collect patent data, the keyword and the appropriate algorithm of these keywords were used as query on the patent search engine, i.e., Orbit™. A huge number of patent document hits were achieved ranging from thousands to zero (in some cases). The conventional text mining of the appropriate patent dataset was done. Extracting relevant information is only possible by the manual text mining. Nevertheless, the chances of misses are also there but the probability of such is defined by the query/queries of the keywords generated in the previous steps and also the search engines capabilities. However, when analysing the searched patent datasets by using various advanced software-run analytical tools, there is addition of one more factor in the probability of the misses which can be overcome in the manual text mining. However, many researches recommend to combine text-based and software run retrieval methods in case of some specific searches like invalidity patent search and freedom to operate search[31,32]. These kinds of high-end searches cannot afford the misses as the penalties in terms of finance and reputations are very high.

In this study, the R&D problem, is so specific that finding a lead for solving this problem was equivalent to finding a needle in hay straw, therefore the researchers used manual text mining along with advanced patent analytical tools. At first, the text-mining of the searched patent databases was performed and the most relevant patent documents were extracted from the huge information gathered in terms of patent documents through patent map analysis and network model analysis.

Patent map analysis was done to understand the technology trend in the area of interest. Patent maps were generated for the selected set of patent documents. The technology trend map of the broad patent dataset, as shown in Fig. 1, showed that remote control drug delivery device is a field wherein a lot of patent documents have been filed over the years. The key areas of interest could be defined by the extensively explored technologies like as defined by the IPC classifications code where heavy clustering of the patents was seen in Fig. 1. Further, to understand the interest of the inventors/assignees, patent maps of assignees/inventors over the IPC classes were generated (Fig. 2 & Fig. 3). As evident from these maps, the focus of the research by the various assignees as well as inventors is defined by IPC classes A61B, G01N and H01L. Although extremely useful information and an overview of the technology is provided by these patent maps, patent maps are subject to some limitations in terms of their limitation providing information only from the bibliographic data thereby limiting the extent of explanatory and creative capacity for the unstructured data/information of a patent document. Therefore, for the purposes of the present research work, the scope of extracting information from patent documents was further strengthened by the advanced patent analytical tools.

Keywords were identified for the purposes of text mining followed by finding the keyword vector of each keyword in each patent document. The patent document dataset comprising 68 most relevant patent documents, screened by the manual screening, was quantified and an intrinsic matrix was developed. The intrinsic matrix comprising the keyword vector for each patent was converted from 2 mode matrix to 1 mode matrix for the better understanding of the network of patents with respect to the keyword vectors. 1-mode analysis examines the interrelations between the same set of patent documents[33]. The 1-mode matrix was converted into a dense network model using the UCINET 6.0 version software (Fig. 4). A 2-mode matrix can be transformed into a 1-mode matrix by taking similarities among the rows (or columns) and then one can visualise the network using all the usual techniques for visualisation of valued networks.

The unstructured data of the patent documents was analysed by using the network model of Fig. 4. The network analysis has dual advantage of visual expression and quantitative values of patents in terms of degree of importance, degree of newness, and degree of similarity. The network model of Fig. 4 substantiated the relevance of searched 68 patent documents. The selected set of patents is most influential among the other searched documents as the network was very dense with a density of more than 1. It further assisted users in determining the relative importance of individual patents. The patents in the most dense part of the patent network model included patent number 55, 63, 13, 46, 30, 24, 54, 68, etc. These patents

were further studied in detail and 14 patents from the densest part of the network were chosen as the leads for the R&D problem. The network analysis of the network model assisted the research to move forward wherein the concentration of above network model helped to isolate 14 patents from the above group.

Patent maps and network-models provided a holistic view of the patent documents. The nodes were well connected and the network was fully formed. Analysis from the network model would provide useful leads to proceed ahead in the present research work. Another quantitative patent index verifying the correctness of the network model is Geodesic Distance[34] The geodesic distance between two nodes is the length of the shortest path. Average geodesic distance between all pairs of nodes in the present network model was 1.0 and the Distance-based cohesion, i.e., "Compactness" of the network model was 0.595 indicating a fairly networked nodes and edges. This is the characteristic value of a network model and in the present research, the Geodesic distance, and distance based cohesion values indicate a well connected network.

The centrality index in patent network is interpreted as the ratio of the number of tied links to other patents. Therefore, the higher the centrality index, the greater the impact on the network[35]. The centrality indexes of some patents are presented in Table 3. It measures the patent documents on the scale of 0 to 1.0 and higher value of the centrality index indicates better relevance of the document. The centrality index of US5694919 was 0.857, indicating a high closeness of this patent document to our problem or keywords. Also for many other patent documents, the centrality index was quite significant. Among the dataset, the patent documents with centrality index of more than 0.5 were considered significant and discussed in detail.

The US 5,694,919 with highest centrality index was found to be most relevant for present R&D problem. This document had highest value of the keyword vectors for all the selected keywords. When studied, it was found to disclose an aerosol drug delivery of a drug from a system. The device is designed for the release of fentanyl in a predetermined manner and with a lock and key arrangement. This was a very useful finding of the present research work as the document was extremely relevant for the present work. Other patent documents also disclose highly relevant technologies for the present problem. The patent map analysis of these patents indicated the clustering of these patents based on the applicants.

A majority of these patents were owned by M/s Novo Nordisk, M/s Animas/Johnson & Johnson, M/s radigm Copro, and M/s Ball Semiconductor. The remotely control drug delivery was the key focus of these patents. Insulin delivery was another major technology discussed in many of the sorted patent documents. All the patent documents and their technology focus is provided in Table 4.

6. CONCLUSIONS

The main objective and contribution of current research was to provide leads solving R&D problem of a remotely controlled drug delivery device having capability to deliver the drug in a predetermined manner as patent documents. The combination of patent analysis narrowed down the result of the patent search to 14 most relevant patent documents. Out of these 14 shortlisted patent documents, US patent 5694919 (Title -: Lockout device for controlled release of drug from patient-activated dispenser Assignee: Aradigm Corporation) disclosed the most relevant aspects of the problem. This patent document was identified from a very narrow set which included keyword combination of “Drug delivery + Inhalation+

Table 4. Leads (patent documents) to solve R&D problem

S. No.	Patent number	Assignee	Title
1.	US5694919	ARADIGM	Lockout device for controlled release of drug from patient-activated dispenser
2.	US5928195	University of pennsylania	Remote control drug delivery device
3.	US6464687	Ball semiconductor	Implantable drug delivery system
4.	US8002700	Medtronic	Communications system for an implantable medical device and a delivery device
5.	US2011004188	Nilimedix, avraham shekalim	Drug delivery system with wireless monitor
6.	US20080147041	Novo nordisk	Device for providing a change in a drug delivery rate
7.	US2008114299	Novo nordisk	Remote commander to be used with a drug delivery device
8.	US2011264033	Novo nordisk	Medical device with value sensor
9.	WO2009112513	Novo nordisk	Drug delivery system with two communicating devices providing continuous drug
10.	US2009105646	Animas	Multi-frequency communication system for a drug infusion device
11.	US8502662	Animas	System for using status indicators in wireless communications with medical devices
12.	US2007233051	Johnson & Johnson	Drug delivery systems and methods
13.	WO200053243	Ball semiconductor	Implantable drug delivery system
14.	US2009326722	Johnson & Johnson	System for using status indicators in wireless communications with medical devices

fentanyl". The important part of this patent is that it is a commercially available product. 'AERx iDMS' from M/s Aradigm Corporation. It was concluded that technology for remotely controlled drug delivery exists and actual products, from reputed company are available in market. However, the filling trend of the most relevant patents also show that it is a comparatively new area of activity and technology is still maturing.

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