Searching for relevant patents using TRIZ and Patent Citation Analysis – a Case Study

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Abstract:

Reviewing prior work and review papers helps to build guidelines to new conceptions in technical and non-technical innovations. The review work is commonly persuaded before patent drafting/filing or new novel research area or new business. Presently the review work is conducted based on journal publications, published patent documents, open web sites, etc. This review work typically depicts past innovations in technology or business. On the other hand Theory of Inventive Problem Solving (TRIZ) approach can help to map inventions in the past, present and future time frame. Further it can help to expand inventions at component level, sub-system level or system level. This helps to identify new opportunities, for science, technology, or business. In this paper we are analyzing prior publications in perfusion imaging by applying systematic approaches such as Patent Citation Analysis and TRIZ, to study the growth trends and explore new improvements. Blood perfusion assessment through Magnetic Resonance Imaging is widely used for diagnosis for different anatomy particularly brain. This paper proposes to replenish the review work done in the past and present. Further the paper shows how TRIZ can be used to explore possible futures in the area of perfusion imaging through Magnetic resonance.

Introduction

Number of new inventions in all fields is growing rapidly. Increasing globalization and exchange of ideas across fields, geographies and countries has led to more and more inventors seeking patent protection for their inventions. In this rapid explosion of patents, it is but natural that patents are granted to inventions that may be very strong or relatively ineffective. The range of strength of inventions for which patents are granted is also increasing due to multiple factors. This leads to a problem of finding strong and relevant patents, not only from the point of reviewing the prior art in terms of patentability of new inventions, but also to define the new arenas for research. In this paper we propose an integrated approach combining social citation patent analysis and TRIZ levels of inventions to find relevant and stronger patents with relatively less effort in the dense forest of patents which is becoming denser every day. The methodology is used to find and analyze patents in the field of Magnetic Resonance Imaging – especially perfusion imaging. In Section 2 we give a brief overview of perfusion imaging. In Section 3 process of finding interesting patents in what is described as the social citation network of a patent is described. Section 4 describes mapping of interesting patents based on 5 invention levels of TRIZ. The paper concludes with Section 5 giving pointers for further application of the methodology.

2. Perfusion Imaging

Magnetic Resonance Imaging (MRI) is extensively used as an image analysis tool for diagnosis of the human body. Today MRI is widely used in defining the soft tissue anatomy, characterization or dynamic study in 4D. There are challenges in Magnetic Resonance (MR) image acquisition and analysis for patient in the area of dynamic study like *perfusion*. *Perfusion is an important process of supplying oxygen, nutrients to the tissue and removal of waste from the tissue. Its analysis is important for the assessment of tissue health and function.* This can be described by several parameters, such as blood flow itself, the volume of blood vessels, the time it takes a particle, such as red blood cells to traverse the vasculature. Perfusion can also be described by the velocity of particles in the blood. There exist two main MRI perfusion methods: bolus tracking after the injection of an exogenous endovascular tracer and arterial spin labeling (ASL), which uses magnetically labeled water protons as an endogenous tracer. Arterial spin labeling has grown very rapidly and advanced the imaging techniques for perfusion imaging substantially. ASL is completely non-invasiveness; whereas the contrast enhanced bolus tracking MRI is somehow invasive as it requires injection of exogenous contrast agents. This feature makes ASL very suitable for perfusion studies of healthy volunteers and in patient groups requiring repetitive follow-ups. Again the contrasts cannot be used in patients suffering from renal diseases because it can have harmful effects. Recent advance in ASL has made its clinical application possible and is being used for quantification as well as quantification of tissue perfusion.

As a first step we start with identifying a key patent in the ASL perfusion technique. For this either a search or prior knowledge of the expert is needed. In Section 3 we describe how to explore the whole field just on the basis of the first patent.

3. Identifying Key patent in ASL perfusion technique:

An important Patent in this field is *US Patent No. 5846197*.

> ***Title*** Compensating for magnetization transfer effects in multislice and three-dimensional MRI blood flow mapping studies
>
> ***Abstract***
>
> *To compensate for magnetization transfer effects that result from use of a labeling pulse to label inflowing blood, at least two control pulses are used. The control pulses have a total compensating flip angle that equals the flip angle of the labeling pulse, and are applied to the same volume to which the labeling pulse is applied. Advantageously, the labeling and control pulses are adiabatic.*

Using this as the central Patent, we construct *Social Citation Network* of a Patent to find out other interesting patents in the citation network of the central patent.

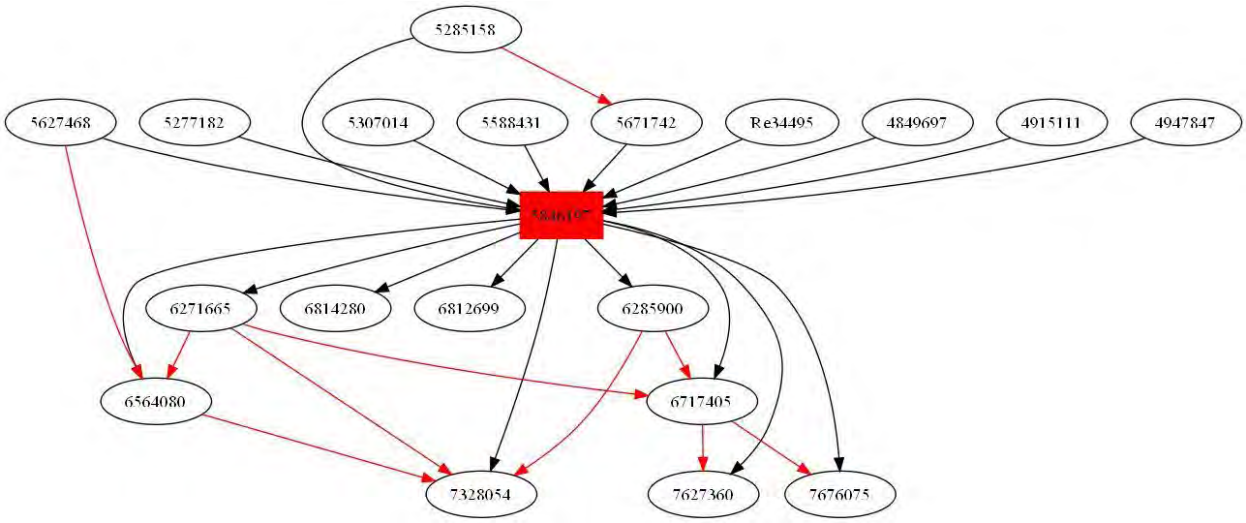
3.1 Social Citation Network Analysis Method

Ego-Centric Citation Network (ECCN) of a Patent (called the central patent) consists of all those patents that either cite the Patent or are cited by the Patent. Besides the ECCN of a Patent has links that connect any two nodes in the ECCN but need not pass through the central patent.

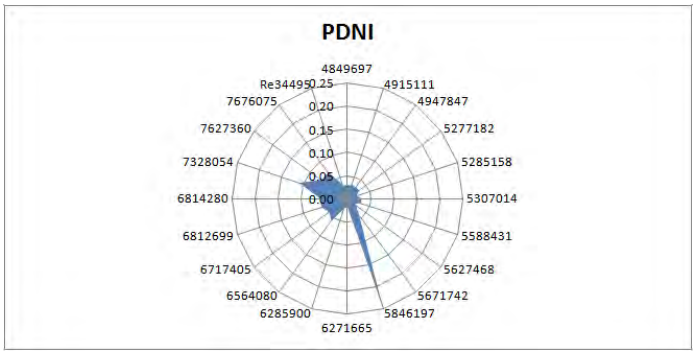
Social Citation Network of a Patent (called the central patent) consists of all patents in its ECCN plus all patents that cite or are cited by each patent in the ECCN of the central patent.

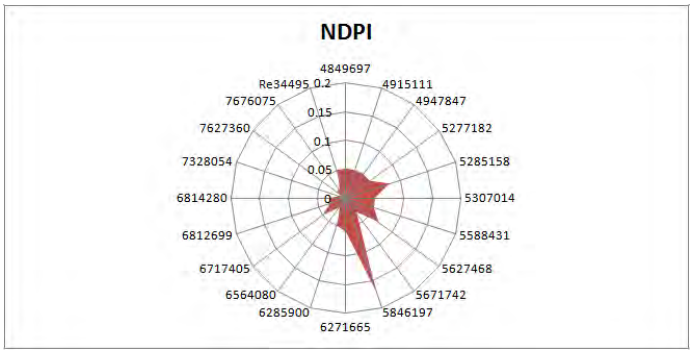
Crafitti's Social Citation Network Analysis measures three indices on these Patents – ***Patent Dependency on Network Index (PDNI*****,** which gives a relative measure of how much the network depends upon the Patent in terms of citation relative to all other patents in the network. **Network Dependency on Patent Index (NDPI)** gives a relative measure of how much patent depends upon the Network in terms of citation relative to all other patents in the network. **The Ego Centric Citation Index (ECCI),** gives a relative measure of how much it cites the other patents and how much it is cited by other patents in the network.

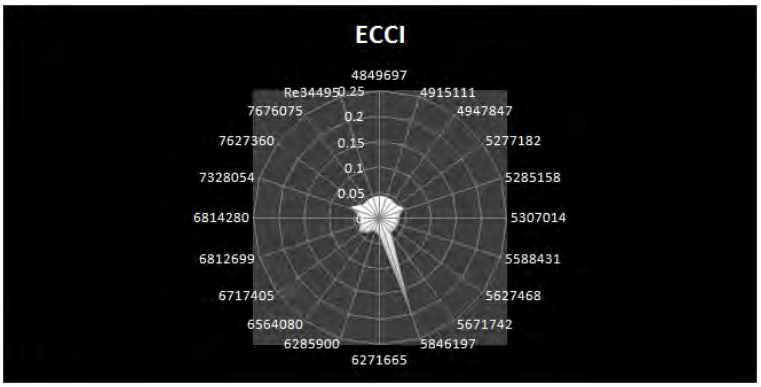
The US Patent No. 5846197's citation network based on citation information available at USPTO (http://www.uspto.gov) is shown below.



The PDNI, NDPI and ECCI of the network are shown in the following figures.



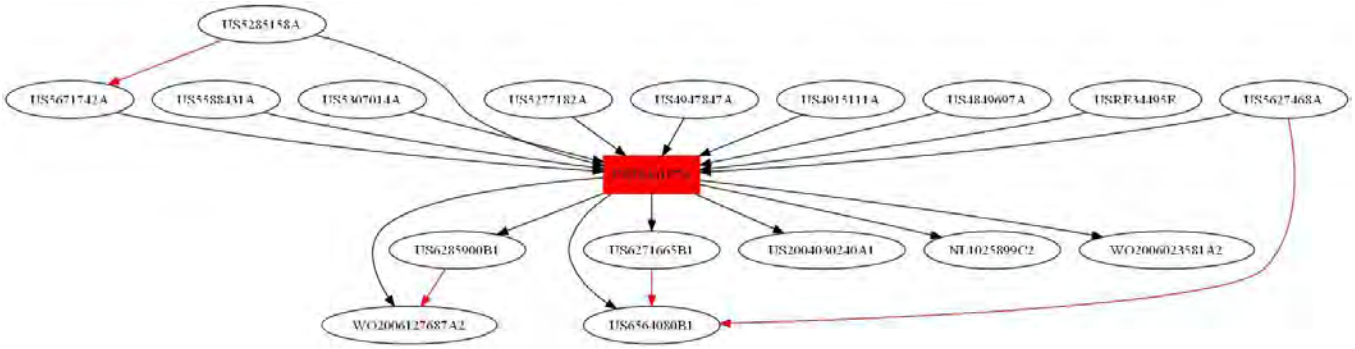




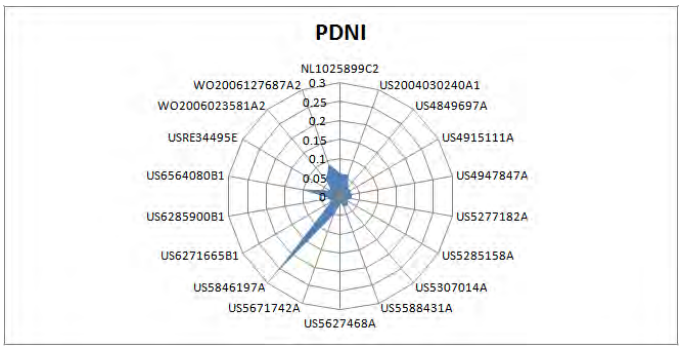
The Table below gives the ECCI, PDNI and NDPI of all Patents in the USPTO network of the said patent.

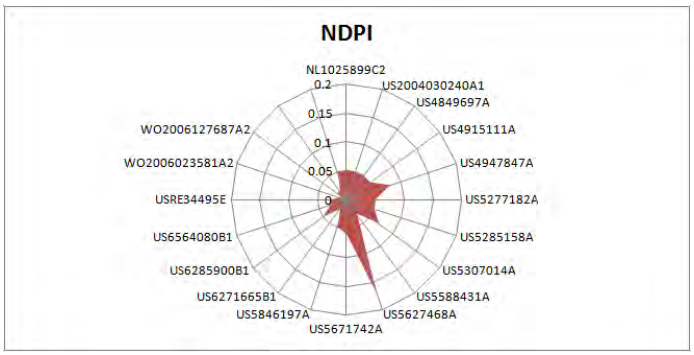
Doc #	PDNI	NDPI	ECCI
4849697	0.03	0.05	0.04
4915111	0.03	0.05	0.04
4947847	0.03	0.05	0.04
5277182	0.03	0.05	0.04
5285158	0.02	0.08	0.05
5307014	0.03	0.05	0.04
5588431	0.03	0.05	0.04
5627468	0.02	0.07	0.04
5671742	0.04	0.03	0.04
5846197	0.24	0.17	0.21
6271665	0.02	0.06	0.04
6285900	0.02	0.05	0.03
6564080	0.06	0.02	0.04
6717405	0.05	0.05	0.05
6812699	0.06	0.03	0.04
6814280	0.06	0.03	0.04
7328054	0.11	0.01	0.06
7627360	0.07	0.02	0.04
7676075	0.07	0.02	0.04
Re34495	0.03	0.05	0.04

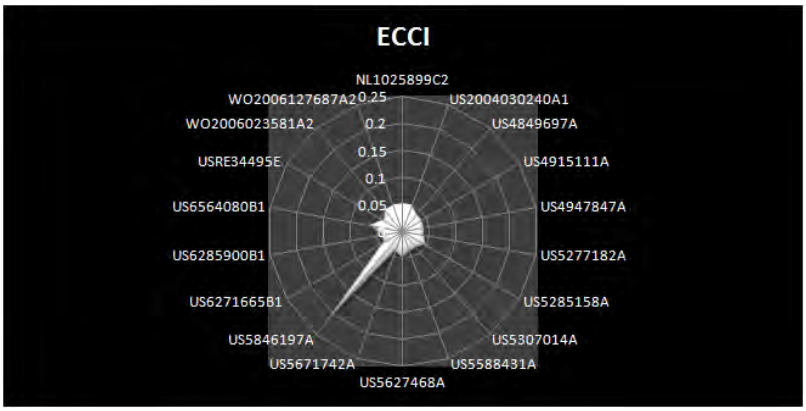
The above analysis is only for the first level citation network at USPTO. Carrying out same analysis at EPO (http://ep.espacenet.com/) gives us the following network.



The PDNI, NDPI and ECCI of the EPO network are shown below.

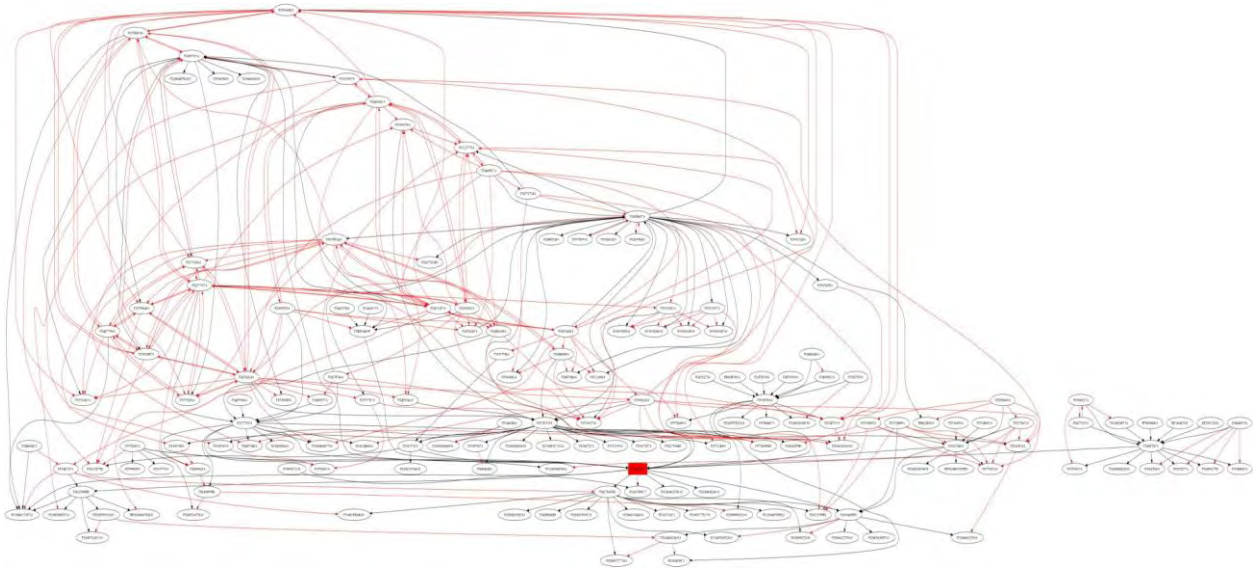




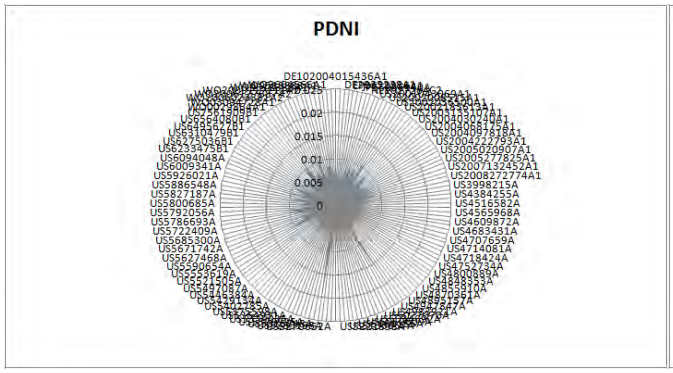


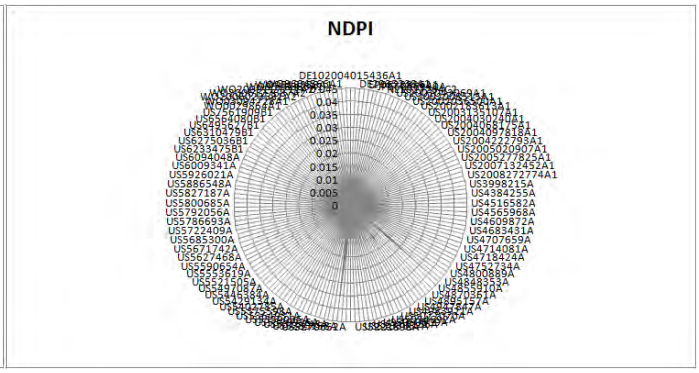
Doc #	PDNI	NDPI	ECCI
NL1025899C2	0.06	0.03	0.05
US2004030240A1	0.06	0.03	0.05
US4849697A	0.03	0.06	0.04
US4915111A	0.03	0.06	0.04
US4947847A	0.03	0.06	0.04
US5277182A	0.03	0.06	0.04
US5285158A	0.02	0.09	0.05
US5307014A	0.03	0.06	0.04
US5588431A	0.03	0.06	0.04
US5627468A	0.02	0.07	0.05
US5671742A	0.05	0.03	0.04
US5846197A	0.27	0.18	0.22
US6271665B1	0.03	0.04	0.04
US6285900B1	0.03	0.05	0.04
US6564080B1	0.11	0.01	0.06
USRE34495E	0.03	0.06	0.04
WO2006023581A2	0.06	0.03	0.05
WO2006127687A2	0.09	0.02	0.05

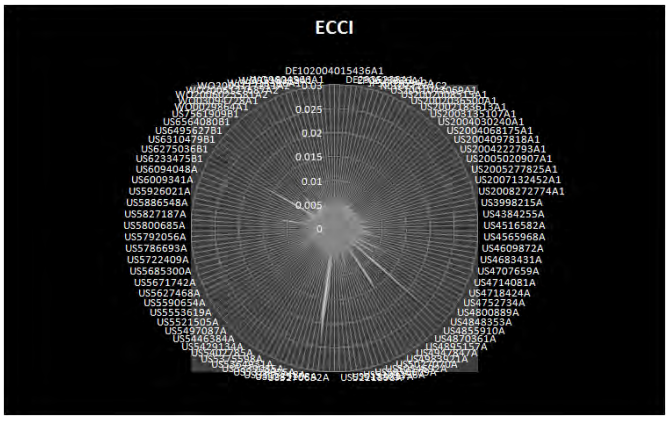
Crafitti's Social Citation Network Analysis can also be carried out for ***second level citation network***. The second level citation network analysis shows the following network at the EPO. *As one can see, without the aid of software, it is not possible to identify the key patents in this network.* Number of patents found in this network are 162. If one has to look at each of these 162 patents, it will be take lot of effort and time. The social citation network analysis method provides us a sorted list of most important patents on the three documents.



The Social Citation Network Analysis applied to this network yields the following PDNI, NDPI and ECCI. The table shown top 20 patents sorted by ECCI index.







Doc #	PDNI	NDPI	ECCI
US4849697A	0.0124	0.0448	0.0286
US5285158A	0.0085	0.0416	0.025
US6271665B1	0.0024	0.0344	0.0184
US5307014A	0.0203	0.013	0.0167
US4947847A	0.0174	0.0147	0.0161
US5277182A	0.0103	0.0169	0.0136
US4718424A	0.0074	0.019	0.0132
US4915111A	0.006	0.0196	0.0128
US5846197A	0.0105	0.015	0.0128
US4777957A	0.0071	0.0151	0.0111
US5627468A	0.0116	0.0099	0.0107
US4683431A	0.0047	0.0157	0.0102
US6564080B1	0.004	0.0156	0.0098
US5190744A	0.004	0.0153	0.0096
US5588431A	0.0009	0.0181	0.0095
US4714081A	0.0025	0.0161	0.0093
US5050609A	0.001	0.0163	0.0087
US4609872A	0.0019	0.0153	0.0086
US4532473A	0.0026	0.0143	0.0085
US4516582A	0.0029	0.0133	0.0081
US4848353A	0.001	0.0152	0.0081
US5225779A	0.0082	0.0079	0.0081
US5034694A	0.0034	0.0126	0.008
US3998215A	0.0033	0.0121	0.0077
US6285900B1	0.003	0.0122	0.0076

One can also see that the central patent that we started with US5846197 actually comes out to be number 10 when you sort the patents in its social citation network using the ECCI Index. As one can also see above the most important patent in this field started is US4849697A. It was filed in 1988 and granted to General Electric (GE) Company. A brief description of the patent is given below

> **Title** Three-dimensional magnetic resonance flow-contrast angiography with suppression of stationary material

Abstract

A metod for providing a three-dimensional nuclear magnetic resonance (NMR) flow-contrast angiograph of fluid flowing substantially only in a predetermined direction, with suppression of stationary material surrounding the fluid, uses the steps of: acquiring a first set of image data from NMR responses generated from a volume-to-be-imaged by a three-dimensional volume imaging sequence preceded by a saturation portion saturing nuclear spins in a volume adjacent to, and in the direction from which the desired flow will enter, the volume-to-be-imaged; acquiring a second set of image data from other NMR responses generated by the same volume imaging sequence, but devoid of any preceding saturating portion; and subtracting one of the first and second data sets from the other to generate a difference data set from which a final image is displayed. Advantageously, a 3DET volume imaging sequence is used, with bipolar flow-compensation used along both axes of flow encodation. The total first moment of all magnetic field gradient pulses, from volume selection tie to echo time, on each of the separate three Cartesian gradient axes, is nulled, with the total area (the amplitude-time integrated product) of the pulses being set substantially equal to zero alaong two of the three axes. The non-zero pulse area difference along the one selected non-readout axis is balanced by a rewind gardient pulse after completion of the response signal readout.

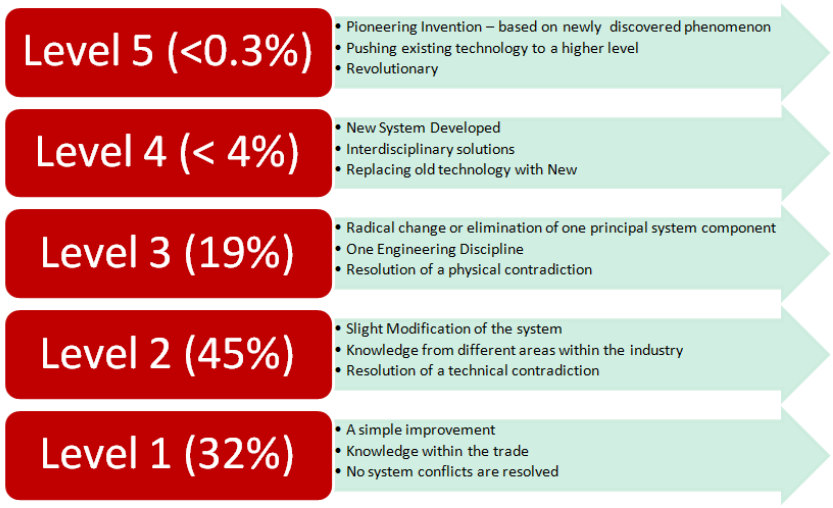
A brief look at USPTO will tell us that this patent has been cited by many patents (25 patents) till now. Although its life is over, it does remain the patent that might have initiated this field. Since there are many patents in the network of 162 patents that may not have much relevance either due to their age or due to legal status (for example not maintained), the experts choose the relevant patents for further analysis.

It was decided to look at only the following patents for further analysis.

Patent Number	PDNI	NDPI	ECCI
US5402785	0.0038	0.0091	0.0065
US5846197	0.0105	0.015	0.0128
US6271665	0.0024	0.0344	0.0184
US6285900	0.003	0.0122	0.0076
US6564080	0.004	0.0156	0.0098
US2004030240	0.0069	0.0031	0.005
US20050277825	0.0066	0.0031	0.0049
WO2006127687	0.0128	0.0009	0.0068
WO2007035824	0.0075	0.0021	0.0048
US20070132452	0.0093	0.0021	0.0057

4. Patent Analysis Using TRIZ Invention Levels

After studying and analyzing more than 2.5 Million Patents and Inventions, Theory of Inventive Problem Solving (TRIZ) has categorized patents/inventions into 5 levels of inventions. 77% of these fall under simple modifications or improvements. TRIZ describes a lens to find out where is on these levels is the patent/invention. A Level 4 Invention is real diamond, but rare. Further TRIZ process helps in finding out what key problems the invention is solving – if the invention solves a contradiction it becomes interesting from the point of view of its increasing strength. Further, TRIZ identified 40 Inventive principles used by inventors. The basic patent analysis gives the level of the invention, contradictions solved by the invention and inventive principles used by the invention. It also gives guidelines on possible principles that could also be used. This is a very powerful input for the inventors to reinforce their inventions.



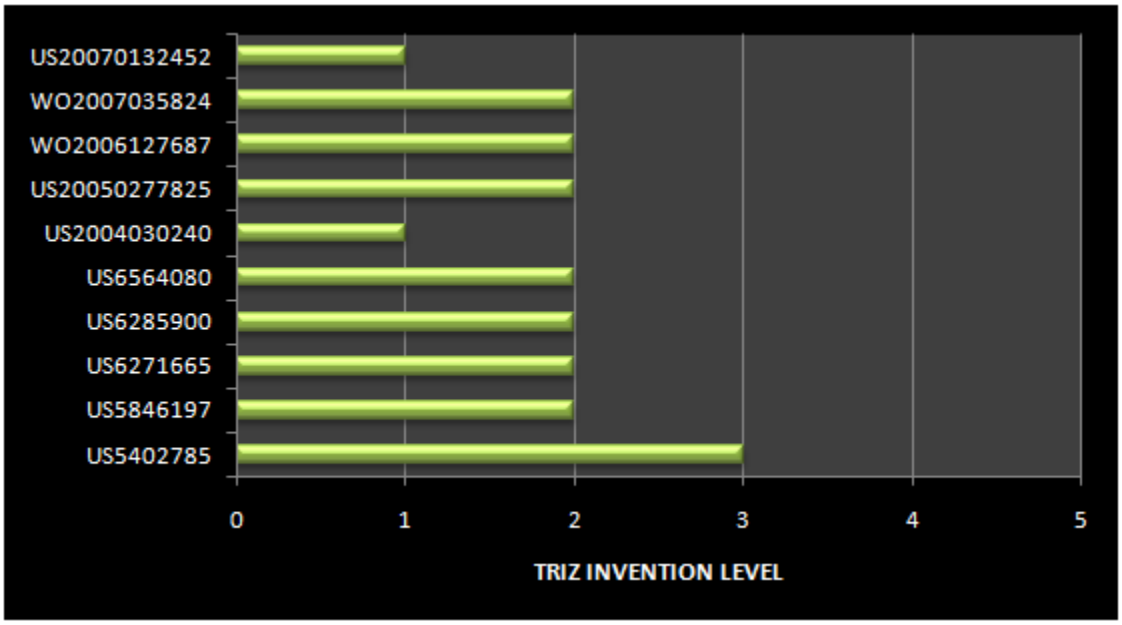
Reading the *central patent* one can decipher that the invention described in the patent document improves the prior art in following three attributes – (a) Use (b) Labeling and (c) Imaging precision. The following table summarizes the key attributes and features of the invention. Since it resolves technical contradictions over prior art – it was mapped to Level 2. It should be mentioned that at this point we are not really interested in the inventive principles used and which technical contradiction has been resolved. Using a simple reading of the invention one can decipher the key problems which are typically defined as technical contradictions, that the invention is resolving.

Patent Number- US5846197			
Sl. No	**Factors**	**Improving Parameter**	**Worsening Parameter**
1	Use	Multi-slice studies, three-dimensional studies and Brain studies	motion-sensitive artifacts
2	Labeling	distal effect (decreased intensity) - Continuous labeling	incomplete cancellation of MT
3	Imaging	Precision – magnetization transfer effects	Complex- Labeling process; Reliability; tagging plane must be carefully placed; increases a transit delay time

Mapping the patents to various TRIZ Levels we get the following picture.

Patent Number	TRIZ Invention Level	PDNI	NDPI	ECCI
US5402785	3	0.0038	0.0091	0.0065
US5846197	2	0.0105	0.015	0.0128
US6271665	2	0.0024	0.0344	0.0184
US6285900	2	0.003	0.0122	0.0076
US6564080	2	0.004	0.0156	0.0098
US2004030240	1	0.0069	0.0031	0.005
US20050277825	2	0.0066	0.0031	0.0049
WO2006127687	2	0.0128	0.0009	0.0068
WO2007035824	2	0.0075	0.0021	0.0048
US20070132452	1	0.0093	0.0021	0.0057

The TRIZ invention level mapping shows the following graph.



As one can see we have found a ***level 3 invention*** – which is US 5402785. A brief description of the patent indicates that it was filed in 1991 and granted to Carnegie Mellon University.

Title: Methods for measuring perfusion using magnetic resonance imaging

Abstract

Methods for measuring the perfusion of fluid in a substance are shown to include subjecting the fluid to electromagnetic energy so as to cause a response related to

the magnetization of the fluid before it enters the substance, performing magnetic resonance measurements on the substance to generate intensity information and processing the intensity information to determine perfusion. In one embodiment of the invention, perfusion is measured by labeling atoms in the fluid at a base point, generating a steady state in the substance by continuing to label atoms until the effect caused by labeled atoms perfusing in the substance, reaches a steady state, generating image information for the substance and processing the image information to determine perfusion. It is preferred to label atoms by applying magnetic resonance perturbation. In one embodiment the labeling of atoms involves saturating spins associated with the atoms. In an especially preferred embodiment labeling involves inverting spins associated with the atoms continuously by adiabatic fast passage. Such inversion is preferably achieved by applying a radio frequency field virtually continuously. The invention is particularly useful where the substance is tissue and wherein the fluid is blood. In such an embodiment, labeling involves labeling the hydrogen atoms of water contained in the blood. It is also preferred for labeling to occur at a point between the heart and the tissue. It is also especially preferred for the generation of magnetic resonance images to involve generating a first image while labeling at the base point, labeling at a remote point, generating a second image while labeling at the remote point and generating a relaxation image. In such an embodiment, all of the images are processed in the determination of perfusion.

If one reads the patent one can see that it describes the invention which solves multiple system parameters and in fact reduces cost as well.

Patent Number- US5402785			
Sl. No	**Factors**	**Improving Parameter**	**Worsening Parameter**
1	Contrast- (Contrast Agent)	Harmful Effect of Paramagnetic Substances (Toxicity)	Precision - geometric restrictions
2	Perfusion measurement (Quantification)	Requirement of Blood Sampling;Clearance time of tracers	Precision - Variation in blood velocity, image signal-to-noise ratio (artifects), reliability and Difficulty in measurement
		Perfusion Can be Repeatedly measured;Labeling Efficiency	Steady state must be maintained; Fixed time
3	Endogenous Water Tagged	Precision – water has high MR sensitivity	Effect of Diffusion, magnetization transfer effects
4	Image Quality	Improved Image quality	The tagging in the control image can result in the excitation of spins in the venous blood; sustraction error- T1 dependance of stationary spin
5	Labeling	easier to implement (adiabatic Labeling)	Continuous labeling; require fast imaging methods, Tagging the heart and other parts of the body would be difficult- tagging plane must be carefully placed
			RF pulses must be applied for long period-Periodic
6	cost	low	reliability

5. Conclusions and Further Work

In this paper we have described a methodology that uses a technique based on analysis of social citation network analysis of a patent with TRIZ levels of inventions to quickly search for strong patents in the large dense fields of patents in multiple technological fields. A real life case study in the perfusion imaging case is presented. It was found that this method enhances the speed of searching for stronger patents in a field and helps in quickly understanding a field which may have high patent density.

This is an initial attempt in exploring the social citation analysis with TRIZ levels of inventions – but it already has shown great promise. In future we intend to apply the same methodology in various fields to see the efficacy and efficiency of the methodology.

Authors

Shashi Bhushan Mehta, PhD, has done his Masters in engineering and Ph.D Delhi College of Engineering under University of Delhi, India during 2005 and 1997 respectively. He is fellow member of I.E.T.E. India and life member of NMRS India. He worked for more than twenty year in different R&D organizations and Industry. After working as Senior Scientist on different R&D projects at Institute of Nuclear Medicine and Allied Sciences (INMAS), Delhi India moved to JFWTC, GE, Bangalore. Presently he is working for IP&S department at Philips Innovation Campus, Bangalore India. He published one book and more than 30 scientific papers in international journals and conference proceedings. His research interests are Artificial Intelligence, Medical Technology, and hierarchical Innovation. He can be contacted at shashi.mehta (at) philips.com.

Navneet Bhushan is the Founder / Director of an innovation co-creating firm, Crafitti Consulting Pvt Ltd. He has worked close to two decades in managing and developing IT, innovation and productivity solutions and has worked in large commercial and government organizations. He is the principal author of Strategic Decision Making – Applying the Analytic Hierarchy Process published by Springer, UK, 2004, ISBN 1-85233-756-7. His current research interests include complexity, open innovation and globalization. Contact Navneet Bhushan at navneet.bhushan (at) crafitti.com or visit http://www.crafitti.com.

Priya Ranjan Mishra has done his PhD from IIT Delhi in Photovoltaic Systems. Before joining IP&S, Philips Bangalore, he worked in R&D labs in Central Electronics, C-DAC, AERF at various capacities. To his credit, more than 20 papers has been published in National & International journals or conference proceeding. He is currently involved in patent analysis of healthcare, lighting and domestic appliances fields. He is also part of team to improve quality/ productivity of patent analysis and vary curious how Triz can help in this regard. Contact Priya Ranjan at mishra.priyaranjan (at) philips.com

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