The Occasional Observer ⟨www.uspto.gov⟩, A New Source for What Is Happening in Operations Research Practice

Frederic H. Murphy
School of Business and Management, Temple University, Philadelphia, Pennsylvania 19122, v5256e@vm.temple.edu

(Professional: comments on. OR/MS implementation.)

Through a series of decisions over the past two decades by the US Patent Office and federal courts, people and companies are now able to patent algorithms, software, and business methods. Many in the computer-science-and-applied-mathematics community were against this development because they thought this would impede the free exchange of ideas. I do not know if this has happened. Nevertheless, one consequence that the government desired is that models and algorithms are now valuable intellectual property. We can see what inventions people value by looking in the United States Patent Office database. It is now available online, and using its search engine, I looked up some of the keywords in the OR/MS index to see what patents have some OR content. Since a professionally done patent can cost between $10,000 and $20,000, the database contains models and algorithms that someone thinks have value in the marketplace. I have one caveat: individuals can patent their ideas without using patent attorneys at the cost of the application fees and their time. Some might do this because they overvalue their work or just want to say they have a patent.

The Data

My cursory search covers the period 1996 through 2001 plus January 2002 (Table 1). So it is not exhaustive and does not show the trends, a topic interesting in its own right. I could not cover all areas of OR because some keywords were too general for the numbers to say anything about the profession. For example, *reliability* had 73,807 hits. Since this word was in common usage long before reliability models were developed, the results do not tell us anything. When I put in *reliability model*, I got 28 records, a far smaller number.

What is striking is the extent to which the words *optimization* and *simulation* were used. Two of the most defining words for our technologies have entered the mainstream. From the number of hits for *queue*, I gather that a lot of effort is going into managing waits of people, bits, packets, and so forth. I saw that bits and packets carried more interest than people. When the terms became more technical and the subject was more specific, the hits were fewer but still impressive, over 6,000 for both words *combinatorial* and *optimization*. When I used *combinatorial optimization*, the number declined to less than 100—not bad, especially when added to *integer programming* at 81.

Linear programming had 381 hits. This is pretty good for a 50-year-old invention. The expression *network flow* returned 241 patents. Getting more technical, I was impressed that *Lagrange multiplier* appeared 78 times. Authors of patents clearly don't mind getting deep into the field.

Outside of *queue* and *simulation*, most stochastic-area terms brought up a moderate number of hits. This could be because many stochastic-area terms are either very technical or part of mainstream culture. The big winner was *decision tree*. Like linear programming, decision trees have been around a long time. Still, this term led to 695 patents.

Neural networks with 3,454 hits outpaced all but the most broadly defined categories. I'm not surprised

Interfaces, © 2002 INFORMS
Vol. 32, No. 3, May–June 2002, pp. 26–29
0092-2102/02/3203/0026$05.00
1526-551X electronic ISSN

since it is a fairly new area and it has been developing since the patenting of models and algorithms has been allowed, while most areas of OR are in the pubic domain because they have been around longer. The number of neural network patents is a warning that we should try to capture new communities within INFORMS since most neural net researchers do not identify with OR.

Genetic algorithm came up with 383 patents. In the broad area of *artificial intelligence*, I found 2,072 patents. And 1,602 came up with *expert system*. OR seems to be more patentable than AI in the aggregate. I suspect this reflects the current states of both fields. OR took off immediately with early critical applications in transportation, refinery optimization, and queuing and then branched out into many other areas. AI has traveled a more difficult road. Clearly, expert systems are useful with 1,602 patents, and neural nets are important learning models. It will be interesting to see what the mix of patents will be in another 20 years.

Some areas did not fare well. *Game theory* had only 16 hits. This reflects the nature of the subject. One rarely gets numbers out of a game-theory model. Typically, one uses game theory to draw qualitative conclusions, simulate military situations, or as a mindset in negotiations or strategic planning. Game-theory models are not patentable models in general. An auction design, however, was patented. Given the current interest in Internet auctions, this may become a growth area for patents in the future. Given the newness of the area and a lag of up to two years from application to patent, we may see the growth fairly soon.

The big winner was *decision tree*.

I tried *multiattribute utility theory* because I was curious to see how technical the uses of decision trees were. One patent is not a strong endorsement. It was in finance and involved the classic risk/return tradeoff. *Data envelopment analysis* did even worse with no uses. The abbreviation DEA had 1,504 hits. However, DEA also stands for a chemical. Among the patents with DEA is "Skin deodorizing and sanitizing compounds," not a topic in OR. I think that the more qualitative the uses as opposed to quantitative, the less likely that a patent would have value because of the greater difficulty of enforcement. One can sell decision-support tools for crew scheduling. However, when one does a productivity comparison using DEA, one sells the evaluation and not the tool.

Keyword or Phrase	Occurrences
Optimization	24,637
Simulation	20,496
Queue	12,331
Combinatorial and optimization	6,097
Neural network	3,454
Computer simulation	2,309
Artificial intelligence	2,072
Expert system	1,602
Network model	703
Decision tree	695
Dynamic programming	652
Inventory management	458
Genetic algorithm	383
Linear programming	381
Learning curve	323
Network flow	241
Stochastic process	188
Waiting line	144
Markov process	140
Supply chain	118
Combinatorial optimization	91
Renewal process	83
Integer programming	81
Lagrange multiplier	78
Nonlinear programming	70
Branch and bound	44
Reliability model	28
Game theory	16
Multiattribute utility theory	1
Data envelopment analysis	0

Table 1: The number of patents by keyword that resulted from my search of the United States Patent Office Database for the period 1996 through 2001 and January 2002 are ranked by frequency.

Application areas such as *inventory*, *supply chain*, or *learning curve* did not generate large numbers. The use of *learning curve* was mostly metaphorical and not technical, from the few patents I read. A company producing children's toys is named Learning Curve.

Examples of the Use of OR

In a scan I conducted without actual counting, what was striking was how many applications were in telecommunications and medicine. I'm not surprised by

the plethora of telecommunications patents. OR is critical to strategy and operations in this industry. The telecommunications industry is capital intensive, and the players plan and operate large, interconnected systems. Large numbers of interrelated decisions have to be made constantly and people with spreadsheets cannot make them.

The extent of the use of OR in medicine was striking to me. However, in conversation with colleagues, I realized that this is a frontier area for the field in both modeling and solution algorithms. The modeling and solving of combinatorial problems associated with molecular design is increasingly becoming an important partner to the laboratory in biology and medicine. For example, the genome project was conceived as biology but was resolved through computing and information technology.

The extent of the use of OR in medicine was striking.

After telecommunications and medicine, the applications were all over the map. I found applications in computing, airlines, manufacturing, finance, and agriculture—most areas of the economy. Here is an airline patent in a familiar area: "Optimization engine for flight assignment, scheduling and routing of aircraft in response to irregular operations." Some patents sounded intriguing but turned out to be less interesting on closer examination. One patent that surfaced from my game-theory search was entitled "Golf club." I was wondering if someone had developed a smart club that made decisions designed to beat the opponent. Then I imagined a foursome in which everyone had smart clubs and the clubs started to game each other. However, the patent turned out to have just a peripheral mention of game theory. Too bad.

Image-processing applications occur regularly. IBM has a patent on matching fingerprint images. Here is the title of one in medicine: "Cell analysis method using quantitative fluorescence image analysis." The abstract includes the sentence "A neural net computer may be used to distinguish true-positive images from false-positive images to improve accuracy of cancer risk assessment."

"Client-side techniques for Web server allocation," was the title of a Lucent patent that uses "probabilistic routing strategies." Linear programming was part of the patent entitled "Computer assisted method of partitioning an electrical circuit." An operations management application is the basis of "System, method and article of manufacture to optimize inventory and merchandising shelf space utilization." These titles exemplify the strange vocabulary of patents. One reason for using such odd titles is to make the patents obscure so that others have difficulty finding them, part of the patenting game.

One does not see many articles on dynamic programming in the current OR literature. However, it turns out to be important in image processing, cryptology, and natural language and speech processing. In medicine, for example, I found "Genomics via optical mapping with ordered restriction maps" as a dynamic-programming application.

We think of decision trees in terms of business decisions. However, they are embedded in some fairly technical tools. Two patents that incorporated decision trees were "System and method for partitioning a real-valued attribute exhibiting windowed data characteristics," and "Method and system for analyzing wafer processing order." This latter one shows that it is sometimes hard to distinguish an expert system from a decision tree because it seems to use the tree search of an expert system while having features of a decision tree. Decision trees are used in medicine in nonobvious ways, such as determining when to discard limited-use medical probes.

Clearly, OR has contributed to IBM's recovery.

In searching on the keyword *simulation*, I found "N-alkyl, N-alkenyl, N-alkynyl, N-aryl and N-fused bicyclo or tricyclo thienyl-, furyl-, and pyrrolyl-sulfonamides and derivatives thereof that modulate the activity of endothelin," and I did not understand it. Nonlinear programming was used in "Optimization of machining with progressively worn cutting tools." The University of Kentucky Research Foundation

holds this patent. It reflects another change in government legislation on intellectual property. It used to be that research done under government grants was freely available to any one. Now universities own the intellectual property. In the prior regime, since no one owned the technology, no one marketed it. The law was changed to give someone an incentive to put the technology to use. Income from patents is now a significant source of revenue for some universities. So, the legislation worked.

The names on some patents were familiar to me because they are members of the OR community. I found patents that included Grace Lin and Stuart Bermon of IBM. Stu's patent, "Method of allocating work in capacity planning," is probably related to his paper in the Wagner Prize Competition. Grace is the practice area representative on the INFORMS board. I found a patent by Ward Whitt at Lucent that is, naturally, related to queuing and a familiar call-center topic: "Dynamic staffing of service centers to provide substantially zero-delay service." Other names were not familiar. Random checks showed that many of the sample of patents I looked at were not by INFORMS members. Maybe INFORMS ought to scan patent owners to recruit new members.

Approximately 10,000 patents are issued each year with some OR content.

Lucent and IBM were company names that cropped up regularly. They have a long history of using OR. Clearly, OR has contributed to IBM's recovery as a major player in the computer industry and to its growth in computer services. IBM has been the leader in patents granted for the past several years. It had 28,366 in the years covered. Lucent had 6,532.

Conclusions

In scanning the patents, I found very few in the mainstream areas of our journals. Consequently, anyone interested in new areas for using our tools should scan this database. You can have fun looking up what friends and acquaintances have patented and what companies use OR tools. You can satisfy your curiosity about whether areas of interest to you are being applied in novel ways.

What I found really interesting is that in the little more than six years my search covered, I found around 60,000 references to OR. This highlights the critical difference between OR and other subjects taught in business schools. All of the other subject areas apply the science model of hypothesis and discovery. That is, they tell you what exists already. Our professional model is the engineering model of invention. This makes us the odd ones out and hurts the status of OR in the business schools where many of us teach.

To those who complain that our field has not met its promise because we have not changed the world, maybe we have not, but approximately 10,000 patents are issued each year with some OR content or reference. We have nothing to be embarrassed about. Using $10,000 per patent as a rough estimate of the cost, 10,000 patents per year means that individuals and companies are spending $100 million a year patenting ideas, products, whatever that rely on some OR. This does not include the development costs incurred by the companies. I say this $100 million demonstrates that we are as relevant as any other business discipline. We just operate under a different intellectual model.