Three Key Success Factors for Deriving Value from Artificial Intelligence
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Artificial intelligence is making tremendous impact already in the world. Some of that impact is indirect and comes from the anticipation of things that may sound like science fiction now, which has led to massive investments in ideas and people. Much of the impact is direct and comes from applying existing AI capabilities to current processes to improve customer satisfaction, decision making, and productivity of people and supply chains. In both cases, there is still a lot of confusion about what AI is and what it takes to use. Following are three major steps toward achieving impact with AI.

Firstly, to leverage AI successfully, you need to be able to measure the system or process you hope to improve or create with AI. Without good measurement, it will be difficult to understand the return on investment (ROI) from AI, and it is possible that your solution is not as good as it could be because that measurement is not driving improvements in the AI technology.

Secondly, experts are critical to AI applications. Data, compute and analytic technologies are also important. But experts know their domain the best and can identify where value is found. Experts can identify the good data and tell you how to make it better. Experts ultimately will be using the recommendations and providing feedback to the AI system to make it better. AI technology is already poised to work with experts, so start working on AI applications that incorporate experts into human-in-the-loop value chains.

Lastly, to make the most of AI technology and institutionalize it in your domain requires understanding the core differentiation of an AI solution: knowledge capture and re-use, and more precisely, a computer representation of knowledge. AI can sometimes look like magic because it does things that people do when it captures and applies knowledge. For example, AI can recommend books or products that complement recent purchases because it knows that these things go together, just like an employee at a bookstore would know. Enabling people to interact, manage, and improve AI systems will require them to interact with knowledge, so understanding how the computer (Al) understands knowledge is critical. But knowledge, and knowledge representation in the AI system, do not need to be confusing things.

What’s The Score? Developing The Right Measurement Capability Is Critical To AI Success

Without good measurement, it will be difficult to understand the ROI from AI. Following is an example involved in defining an AI system to improve help desk tickets for a large IT provider. They received hundreds of tickets per hour across a global customer base. The leadership identified a key question for the AI system to answer: Given a new IT problem by a user, what is the first resolution they should attempt?
Initially, the company wanted the AI system to generate a recommended set of actions to resolve new problems by mining previous cases and solutions. After several interviews and discussions, a new set of related challenges were identified. Despite having a global network of employees solving similar tickets at the same time, employees were having difficulty properly labeling new tickets and their successful solutions consistently. This labeling challenge made those tickets either difficult to find or invisible to other help desk employees at the time when they would be most helpful -- solving a nearly identical ticket occurring in the same time period.

During discovery, it was apparent that it was difficult to measure outcomes of recommendations the employees made. Sometimes tickets were not closed correctly or lacked important metadata to understand if all the recommended actions were necessary and correct. This experience taught a vital lesson about what dictates the success of AI projects.

**Develop A System Of Measurement**

What is AI and how does it provide value to large industrial companies? Despite many differences between companies, the common goal of AI remains the same: to improve productivity within an organization by allowing employees to make better, more informed decisions.

Conversations about AI often focus on the potential and certainty of an outcome the AI solution can deliver (e.g., decrease customer IT tickets by 10% or decrease the time it takes to close IT tickets by 20%?). However, these overall business goals may not directly align to the type of measurement the AI system will need to be successful: What specific actions did a customer follow to resolve an IT issue, and which of those were successful?

The company wanted an AI system to improve the IT ticket resolution process and provide better customer and employee satisfaction. The initial system design was toward recommending steps to resolve the issue, but the success of that system would be predicated in part upon measuring the outcomes of the employee recommendations. However, it was a struggle to find an immediate path to measuring the outcome of those recommendations directly, rendering the design of the AI system incapable of improving the ticketing process.

Being successful in AI applications requires solving this joint problem of finding the most effective outcome -- for the business and customers -- that also has the data and measurement capability needed by an AI approach. Without the ability to measure the recommendation outcomes, an AI system will fail in the long term or become very costly to maintain.

**Combine Subject Matter Expertise With Data**

To create a better AI solution, you need to leverage the domain expertise of IT employees with the data that a system collects. In this situation:

- Employees were primarily able to store and retrieve their domain knowledge using labels given to previously solved IT issues.
- They struggled to assign labels during the resolution process that were consistent across all their employees.

The solution was an AI system that would recommend a label, intermittently gather feedback from the employee about whether the label was correct and use the feedback to continually improve the labeling AI system. This solution was met with positive feedback from the IT employees, as it allowed them to still apply their experience and technical knowledge while assisting them at the tedious tasks of selecting the best label for every new ticket. It also had a future advantage of preventing new tickets by allowing IT engineers to see trending issues better and head them off.

**Tell The AI System The Score**

Imagine that instead of optimizing IT tickets, you’re developing an application for field engineers at a large energy company. Their goal is to keep critical infrastructure working, in part by prioritizing which pieces of equipment at which customer locations require inspection or repair based on maintenance schedules or predictive maintenance algorithms. In this opportunity, the number of possible objectives and measurements increases significantly to encompass the health of equipment, the efficiency of servicing support contracts, satisfaction and profitability of the customer and overall productivity and satisfaction of the field engineer.
For this scenario, like many other industrial scenarios, success is often not as easily measurable for an AI system. Overall, a company tries to make an objective -- but still often subjective -- decision as to the success of its maintenance actions and productivity of its employees. Businesses develop competitive business models and processes that benefit directly from the domain knowledge and experience of employees. The experience-based knowledge allows businesses to differentiate and provide ever-improving capability to customers. Thus, when developing an intelligent solution using AI, organizations must begin by considering the following:

- Understand what business question the AI system is answering and how you will confidently measure the outcome.
- Identify how the AI system can complement the expertise of its users, allowing it to gather feedback and improve over time.

Pinning those subjective and experience-based decisions down into concrete data and measurements that an AI algorithm could make use of is often very difficult. Therefore, being able to tell an AI system the “score” based on a measurement capability -- so it knows if it is winning or losing and can learn -- is the first step toward achieving value from AI. Combining that score with feedback from users based on their experience and domain knowledge allows the AI system to improve over time.

Three Ways Expert Knowledge Enables Artificial Intelligence

In engineering businesses where something is manufactured or assembled, specifications tell suppliers qualities and characteristics of the material they or customers require. Specifications could be based on physics (temperature ranges) or business objectives (material preferences that allow them to achieve cost efficiencies at scale). Specifications are also one way for businesses to make data-driven process improvements, like optimizing supply chains. Businesses often ask:

- “Given our set of specifications, can we reduce or combine them and still meet our customers’ engineering needs?”
- “Can we do so while optimizing our supply chain by saving time?”
- “Can we simultaneously minimize the diversity of activities we might need to support in the future?”

This example represents an important use case in many places where artificial intelligence can provide quantifiable value. Experts typically capture their knowledge and reasoning about complex knowledge like specifications in unstructured text (comment fields attached to documents, manually written reports) to draw upon later. However, standard search technologies and data-mining solutions tend to fail when required to retrieve that knowledge. Search technologies struggle to account for relevant factors that are most important for specific events, like which factors are relevant in different engineering specifications.

To allow AI to help experts make better decisions and answer critical questions about engineering specifications, the AI solution first needs to learn how to leverage the knowledge coming from the expert. And that knowledge is usually not just book knowledge -- it is heuristic and experienced-based knowledge gained from many years on the job. Below are three ways using expert knowledge in an AI system helped answer questions and optimize the business:

1. Expert Knowledge Allows AI To Convert Text Into Useable Data Points

AI applications are challenging to build because businesses and users rely heavily on experience-based knowledge obtained through years of solving similar challenges in different situations. AI applications must achieve something functionally similar, even if they do so in a different way. Experience-based knowledge is similar to our visual system’s ability to identify and understand complex patterns in pictures: We quickly identify concepts and patterns in a picture and, through our prior experiences of similar patterns, infer what might have led to the image and simultaneously predict what might happen next to fully understand the picture.
Our brain can look across experience-based knowledge captured in text in a similar way to associate prior experiences, identify the most important factors in the current situation and suggest the best solutions to problems. However, with expertise captured in text in a business, we first must identify meaningful concepts, relationships and patterns from the text and documentation. Natural language processing (NLP) is an AI technique that experts can train to recognize from documents important entities, events and relationships between those events and entities. By allowing the expert to label important entities and their relationships, NLP technology helps turn knowledge from these documents into something computers can process: useable data points that represent experience-based knowledge.

2. Expert Knowledge Allows AI To Organize Data Into Meaningful Graphs Or Networks

Engineering specifications can contain hundreds of characteristics, described by various measurement types and attributes. Some are standard and others customer- or project-dependent. The formats of specifications can vary between business units and over time, making normalization into structured databases resource-expensive and error-prone. Specification management tools exist, but even when organizations use them well consistently, variations still arise due to how different parts of the business use them and how use over time changes.

A knowledge representation in some form -- semantic technology, knowledge graphs, association networks -- provides a richer understanding of the domain and the normalization of relevant data. By allowing the expert to easily organize concepts and their relationships into a knowledge representation, which is then mapped to underlying data, the AI application can perform inference that spans things like different measurement units, data formats or data hierarchies.

3. Expert Knowledge Improves AI Techniques

Another method was tested, a logic-based approach for answering questions about engineering specifications -- formal ontologies modeled both the domain as well as the specification, machine learning extracted specifications from documents and logic-based rules were captured from experts to represent heuristics and domain knowledge. The approach encountered difficulties for two reasons: 1) It was difficult to avoid errors while capturing specifications into formal logic, and 2) the logic used to compare and understand specifications was often hard to capture due to its fuzziness and inconsistencies.

AI Leverages Expert Knowledge To Answer Valuable Business Questions

AI systems can help propel businesses forward to make better decisions, but they must be designed to incorporate expert knowledge and use it effectively to answer business questions. Most AI technology requires significant engineering work to customize it and make it perform in a specific domain, and only by putting the expert into the middle of that customization will AI systems be able to be created and perform efficiently.

Better AI Solutions With Knowledge Representation In Three Examples

Businesses are improving their decisions with AI technology. A decision is the action that results from AI answering a question. For example, a business might ask the question, “What is the best route for a delivery truck given its origin, destination and current traffic?” AI technology then generates the best possible answers. The decision the business makes is to select a route given those answers.

The AI technology generates possible answers by connecting the concepts expressed in the question to underlying concepts and analytics. Concepts in the above question are “route,” “truck,” “origin” and “traffic.” This process of connecting the business question to the answer with a computer program involves knowledge representation -- an important but often misunderstood concept.
Knowledge representation refers to the way the technology models “things” in the solution. A good knowledge representation will provide several important capabilities that include:

- Allowing anyone to look at the solution and have a basic understanding of what it is
- Enabling productivity by making the concepts in the solution re-usable and extensible.
- Here are three examples to help you better understand the value of knowledge representation.

### Clearly Define Decisions To Guide AI

Our Chief Data Scientist had previously led an R&D effort to develop a search technology prototype that provided “contextual” results for a message board-based community focused on health and beauty topics. Our goal was to grow engagement and community with a more useful search engine. His team developed an AI technology that re-ranked a partner’s search engine results based on the information and perspectives of the community. A popular example was if users typed “how to harden nails,” the system would remove any results about the nails used with hammers in construction and only return results about fingernails. The team:

- Built a very large SQL database of webpage and link data.
- Fed training data to a machine learning system.
- Converted a user’s search query to a new query that would produce a more contextual set of results.

After initial interviews and data analysis, the team formalized users’ decisions as: Given the community-contextualized search results, would users click on them -- an action that required leaving the community -- then return to conduct more searches? The outcomes of the decision were directly linked to how we monetized the community by an engaged, specific demographic of users that returned frequently and for large amounts of time.

Clearly defined business objectives helped provide common direction among developers, business sponsors and users. But the solution lacked some other critical representational features. To fully understand, re-use or extend the system, one would need to study the machine learning code, data preparation code and database schemas in detail.

### Specify The Decision’s Question And Answer As Concepts

Later, the team tried to integrate high volumes of sensor (internet of things) data coming from large, rotating machinery running in test locations and at customer sites. The team had to integrate IoT data with engineering design data and expensive simulation data. The decision -- a question in this case -- was: Given a current asset, what performance guarantees can be made for specific location and output constraints? If the decision is to set guarantees too aggressively, customers may be disappointed if the machinery’s performance did not meet those guarantees. Setting the guarantees too low would mean not being competitive during bids.

Answering this question required gathering all the high-value data about the machinery and feeding it to a performance simulation model calibrated by real-world data. After specifying the decision’s question and answer as a set of concepts, the team:

- Leveraged open-source, linked data (the Semantic Web, World Wide Web Consortium) to build an ontology that brought together many complex data systems into one flexible knowledge graph-querying platform (SPARQL endpoint).
- Developed a UI to make it easy to select the concepts in the question and those required for the answer, find the best path between those concepts and add constraints (essentially building a complex query).

Using a knowledge graph to align the data model and data access directly to the business question and concepts made understanding, usability and re-use of that data much easier. In this case, the knowledge graph was simply like a database that provided data access in concepts and patterns humans more easily
understand. But since the real decision came only after sending that data to another system, part of the knowledge about how to answer the question was not captured directly in the representation. Also, there were fewer opportunities to improve the system’s answers based on the outcome of the decision.

Extend The Knowledge Graph With the Analytics Needed To Answer The Decision’s Question

In a recent proof-of-concept application, the team developed the answers for decision-making to the following question: “Given plans to drill a well in a region and the problems encountered by nearby drilled wells, what is the best cost estimate of the new well?” This decision was critical in planning investments and business success.

Using the concepts from the question and answer, the team first created a knowledge graph of the main concepts: the well, location, drilling problem and activity logs. They used NLP technology to extract drilling problems from activity logs and then hydrated the other concepts and relations with structured data sources. Similarity calculations and text classifiers for predicting future problems were represented directly as functions in our unique knowledge graph platform. This graph of concepts, relations and functions made the question and how the answer was calculated both understandable and extendable. Additionally, the overall productivity of developing future decision support applications was increased as these concepts (both data and functions) can be reused and improved.

Representation Delivers Value With Understandability, Reusability And Productivity

Many people coming to AI for the first time confuse representation with “symbolic” AI or a particular type of AI technology. Representation is in every AI solution, and with a good representation that captures knowledge about the business decision, the data and the analytics that deliver answers for decision making, AI technology is better -- and, in my opinion, more likely to succeed in the long term.

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