AI and Its Uses in Simulations

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ABSTRACT

Intelligent reasoning by computers has been a goal of computer scientists ever since computers were first invented in the 1950s. This task became known as artificial intelligence (AI). AI has experienced several waves of optimism, followed by disappointment and the loss of funding, followed by new approaches, success and renewed funding. The use of AI in simulations has followed a similar path of ups and downs. There were many papers in the 1980's, followed by fewer papers in the 1990's, then followed by more papers in the 2000's. As computers have become more powerful and AI is becoming more commonplace in other fields, AI is expected to have a bigger impact in simulations. Since simulations are an important part of business education, students should soon see the uses and power of AI.

INTRODUCTION

In computer science, artificial intelligence (AI) is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans. Artificial intelligence is often used to describe machines (or computers) that mimic "cognitive" functions that humans associate with the human mind such as "learning" and "problem solving". As machines become increasingly capable, AI expanded to include many more tasks. Some refer to AI as whatever hasn't been done yet.

The field of AI research began at a workshop at Dartmouth in 1956. Attendees Allen Newell (CMU), Herb Simon (CMU), John McCarthy (MIT), Marvin Minsky (MIT), and Arthur Samuel (IBM) became the founders and leaders of AI research. They and their students produced programs such as computers playing chess better than the average human (Simon, 1991). By the middle of the 1960s, research in the U.S. was heavily funded by the Department of Defense and laboratories had been established around the world.

In the years that followed, AI has experienced several waves of optimism, followed by disappointment and the loss of funding (an "AI winter"), followed by new approaches, success and renewed funding. For most of its history, AI research has been divided into subfields that often fail to communicate with each other. These sub-fields are based on technical considerations, such as particular goals (machine learning), the use of particular tools (artificial neural networks), or deep philosophical differences. (Gupta, 2019)

In the twenty-first century, AI techniques have experienced a resurgence following concurrent advances in computer power, large amounts of data, and theoretical understanding. AI techniques have become an essential part of the technology industry, helping to solve many challenging problems in computer science, software engineering, and operations research.

The use of AI in simulations has followed a similar path of ups and downs. There were many papers published in the 1980's, followed by fewer papers in the 1990's, then followed by more papers in the 2000's. As computers have become more powerful and AI is becoming more commonplace in other fields, AI is expected to have a bigger impact in simulations. Since simulations are an important aspect of business education, business students should soon see the uses and power of AI.

AI USES IN OTHER FIELDS

Technology is transforming industry. Across the board, digital transformation is cutting costs, extracting key insights from large quantities of data, and helping companies prepare for the next generation of competition. AI is at the forefront of this movement. AI has been used to define a broad spectrum of concepts. In short, it describes the idea that machines can be taught to complete tasks in a way we would consider intelligent. One of the most exciting of those applications is Machine Learning (ML). Using algorithms to identify patterns in data, track the results of the actions taken, and actually learn from its successes and failures, ML represents an new way of injecting technology into business processes. (Argyle, 2019).

ML empowers better diagnostics and more efficient services in the healthcare industry. It provides a robust, personalized customer experience in retail and banking. It extracts invaluable market intelligence for advertising and content campaigns. It literally transforms businesses in ways that we are still discovering. It is only one part of a broader suite of digital technologies that are set to save companies billions of dollars per year, but it is the most exciting and likely most impactful. Part of what makes ML a transformative tool is its ability to surpass the capabilities of human operators when evaluating large stores of data. Where humans could only skim the surface of the 2.5 quintillion bytes of data created every day, machines are exponentially more capable. Deep in the big data stores of the world's largest companies are insights that will guide the future of those companies. (Argyle, 2019).

There are many examples of firms, both large and small, using AI and ML in various ways. Thokala (2019) showed how his small firm, BI Technology Services, is using AI to identify data anomalies, to predict sales, and resolve cash flow issues. Carnegie Mellon University is collaborating with the city of Pittsburgh, to evaluate and develop a global model for smarter city solutions. Software is powering traffic signals to communicate with one another, decreasing commute times and emissions (Argyle, 2019). Finally, many automobile firms and/or technology firms are looking at autonomous cars and trucks as a big part of their future business.

There is no stronger proponent of integration of AI capabilities than the Department of Defense – but for conventional weapons, not nuclear weapons. When asked if the DoD could use artificial intelligence to make better decisions, to make more informed judgments about what might be happening, and to reduce the potential for civilian casualties or collateral damage, former Secretary of Defense, Patrick Shanahan said, “I’m an optimist. I believe you can. It will not *eliminate* all problems, however, since it is war and bad things are always going to happen” (Breaking Defense, 2019).

One final example of current and future uses of AI concerns the classroom. Will tomorrow’s classroom look like today’s smart home? Is AI in the classroom a boon or a curse? How can educators and technologists work together to develop tools and methods that facilitate the learning experience? Can intelligent learning promote personalized intellectual exploration? These questions were answered as a yes at a recent Stanford Graduate School of Education and the Stanford School of Engineering webcast. (Stanford, 2019)

SIMULATIONS FOR BUSINESS EDUCATION

A capstone strategy class is usually one of the final courses taken for both undergraduate and graduate business programs. This course integrates all the material from previous classes such as marketing, accounting, and finance. Students draw on their awareness of various environmental influences (social and political) to solve business problems. They examine management alternatives with an ethical perspective relating policy trends to the strategic planning mode (Anderson and Coffey, 2004).

The purpose of a capstone course is to integrate the learning achieved in individual business courses taken to earn a business degree. The knowledge acquired in finance, accounting, operations, management information systems, marketing, and organizational behavior classes is utilized to study the strategic management of the firm as well as the responsibilities of the general manager. The use of extensive case studies embeds sets of knowledge in the minds of the business students. This model has proven effective and has been copied by business schools worldwide (Chasteen, 2014).

Another approach to integrating the learning achieved in individual business courses taken to earn a business degree is the use of simulations. Students participate in a simulation that requires taking into account multiple decision-making factors while balancing all sectors of the firm’s environment. According to Dale (1969), an active learning method can provide even better results. Therefore, simulations have become a standard part of many US undergraduate and graduate capstone strategy courses. They are also common in strategy courses in many other countries (Hall, 2015).

AI USES IN SIMULATIONS (PREVIOUS)

The use of AI in simulations has followed a similar path of ups and downs as AI in general. By surveying the list of papers in the ABSEL proceedings as shown on their website, it can be seen that there were many papers published in the 1980’s, followed by fewer papers in the 1990’s, then followed by more papers in the 2000’s. A few of the more important papers are discussed below.

Varanelli et al (1987) propose an experiment that would be an initial step in building a comprehensive expert system model that will simulate strategic scenarios in the evaluation of policy and strategic circumstances affecting a contemporary organization. The experiment should contribute to the growing interest by the business community in the applicability of expert systems to business decision making.

Sondak and Briggs (1988) show how expert systems are receiving a tremendous amount of attention in the data processing and business communities. But few business educators have been exposed to the base concepts of expert systems or can appreciate the effect they will have on business. The structure and operation of a typical expert systems is presented and development tools and expert system shells are discussed. As expert system development tools become commonplace, business educators should become as proficient with expert systems as they are now with spreadsheets.

Gautschi and Prasad (1988) describe an initial step that was taken to develop an expert system to be used with a business simulation program. In view of the increasing importance of business simulation and its requirement for greater reality; and the emergence of AI technology, in particular expert-system technology; the question becomes not whether Al will have a place in simulation; but when and how.

Aiken et al (1997) state that for years, artificial intelligence applications, in the form of expert systems, have assisted academic and professional researchers in the creation and application of marketing system simulation. Now, due to advances in technology, neural network applications have resurfaced in the marketing literature as a useful tool for the marketing researcher. Their paper describes a simulator that employs a combination of expert systems and neural network technologies.

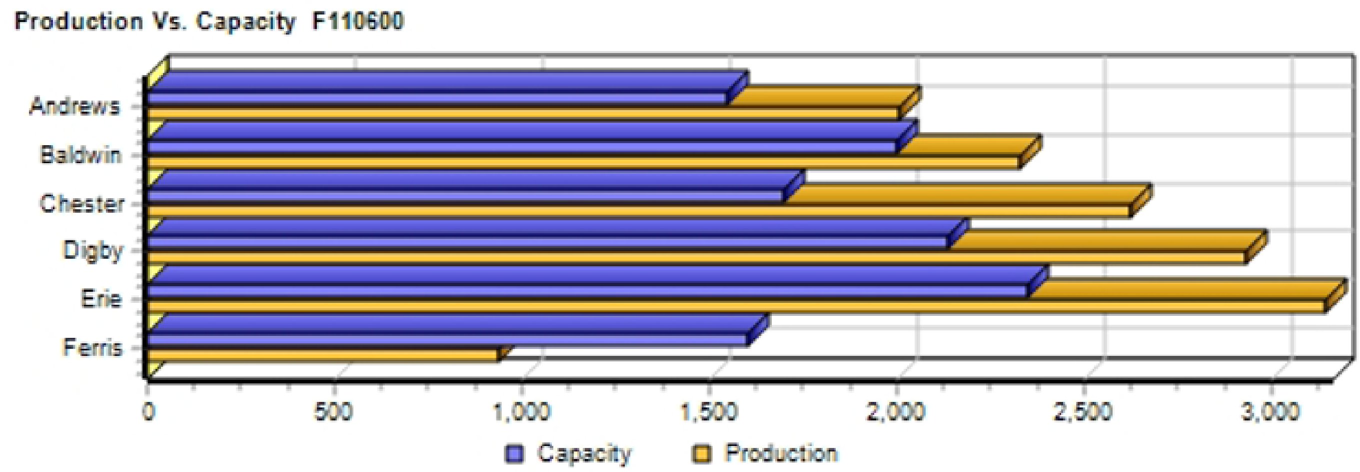
And finally, Baptista et al (2014) state that a number of agent-based models of consumer behavior have been proposed in recent years, but they are seldom adopted in most business games. The advantages of agent-based models are yet to be fully grasped by the business simulation community, who continue to favor equation-based models over the agent-based alternative. They review the major contributions to the field of agent-based models of consumer behavior.

AI USES IN SIMULATIONS (CURRENT)

As computers become more powerful and AI is becoming more commonplace in other fields, AI is expected to have a bigger impact in today's simulations. In the near future all but the simplest simulation models should incorporate AI either in the model itself or in the development of the model. A few examples of current applications are discussed below.

FIGURE 1
Group 1 decisions for computer teams A and B

Production Analysis **F110600** **Round: 6** Dec. 31, 2025



Name	Primary Segment	Units Sold	Unit Inven tory	Revision Date	Age Dec.31	MTBF	Pfmn Coord	Size Coord	Price	Material Cost	Labor Cost	Contr. Marg.	2nd Shift & Over-time	Auto mation Next Round	Capacity Next Round	Plant Utiliz.
Able	Low	1,895	133	1/15/2025	2.4	20000	8.7	11.3	$33.00	$11.37	$5.18	47%	43%	7.0	1,150	142%
Andy	High	374	0	7/9/2025	0.5	22000	10.2	9.8	$43.00	$14.34	$9.11	45%	100%	4.5	800	94%
Baker	Low	1,653	198	7/22/2025	1.7	18800	8.7	13.1	$29.10	$10.94	$6.18	38%	8%	7.5	1,300	107%
Bold	High	1,149	0	4/10/2025	1.6	22400	10.3	8.6	$41.90	$17.33	$10.47	33%	36%	4.0	750	134%
Best		0	0	3/9/2026	0.0	0	0.0	0.0	$0.00	$0.00	$0.00	0%	0%	4.5	450	0%
Cake	Low	1,608	174	6/20/2025	1.6	20500	7.3	12.7	$30.00	$9.16	$4.35	52%	64%	8.0	1,100	162%
Cedar	High	846	0	6/26/2025	1.4	20500	11.6	8.4	$42.00	$16.09	$6.97	45%	42%	6.0	600	140%
Daze	Low	1,732	80	5/18/2024	2.9	19500	8.5	11.5	$34.00	$11.46	$9.41	36%	45%	5.0	1,075	143%
Dabble	Low	905	246	2/27/2024	2.8	16000	7.0	13.0	$33.00	$7.92	$12.93	32%	62%	3.0	603	160%
Dude	High	630	0	4/4/2025	2.0	20000	11.2	8.8	$44.00	$16.21	$4.10	52%	0%	8.0	455	94%
Eat	Low	1,089	0	6/25/2024	2.7	19800	7.0	13.6	$33.30	$9.08	$9.92	42%	38%	4.8	800	136%
Egg	Low	1,102	0	6/16/2024	2.4	19000	6.8	13.0	$32.50	$9.17	$13.57	29%	16%	2.0	950	115%
Enn	Low	400	564	3/9/2025	0.8	19800	6.4	13.8	$33.00	$8.31	$13.68	21%	100%	3.2	850	161%
Fast	High	697	0	4/24/2025	1.6	21000	11.0	10.0	$43.00	$0.00	$0.00	38%	0%	4.0	700	0%
Food	High	665	0	5/29/2025	1.5	21500	10.5	9.7	$46.00	$16.29	$7.95	44%	0%	5.0	500	79%
Fad	High	635	0	5/6/2025	1.4	20500	9.7	10.3	$42.00	$14.71	$11.97	36%	37%	3.0	400	136%

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Capsim

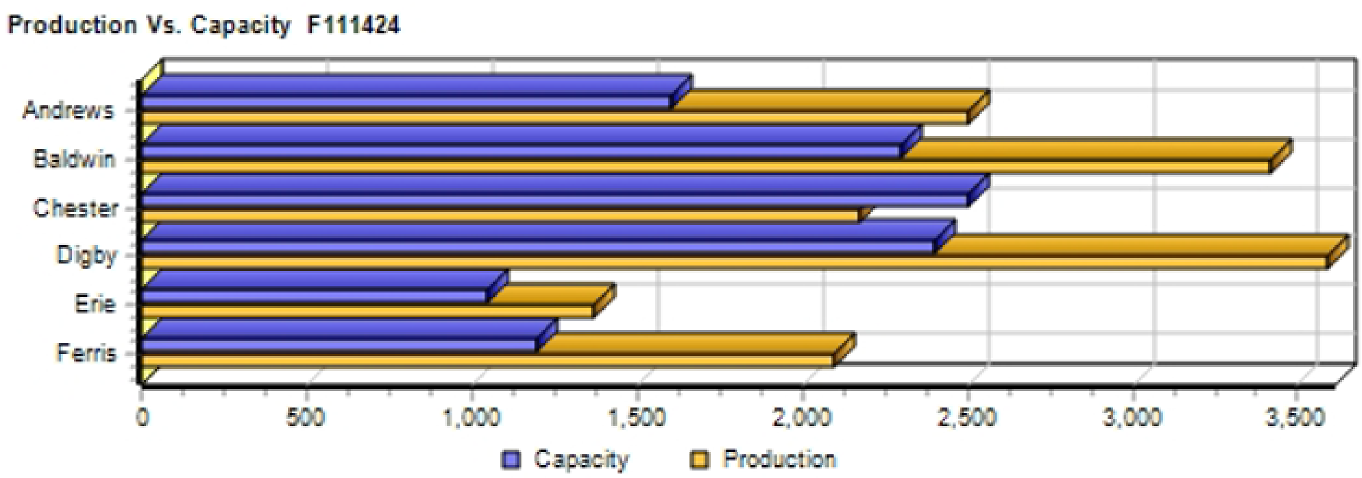
Capsim, a leader in business simulations, is looking into AI for several of their simulations. One possible application is for their Capsim Inbox. Capsim Inbox is a simple and objective way to measure key soft skills that employers look for in a job candidates while providing actionable feedback for development. It is a simulated email experience that measures career skills with every reply. Individuals are immersed in a role at a fictitous company and must choose what they believe are the best responses to various real-world scenarios. Responses indicate proficiency levels on the skills being measured, such as communicating, priortizing, managing talent, and generating solutions. Capsim is considering using Natural Language Processing as a better way to evaluate student responses and actions (Langen, 2019).

Another possible use of AI by Capsim is in their business simulations. Their business simulations engage students in a dynamic competition to turn struggling companies into successful, profitable businesses. Students are divided into teams that compete against each other by making strategy, finance, production, and marketing decisions that interact to grow their business. With each round of decisions (each representing a full year for the company), student teams build their business decision-making ability as they interpret data, shape strategies, and discuss the results **(**www.capsim.com, 2019**).**

Depending on the class size, some classes use computer teams as one or more of the six competing teams. Currently, the

FIGURE 2
Group 2 decisions for computer teams A and B

Production Analysis **F111424** **Round: 6** **Dec. 31, 2025**



Name	Primary Segment	Units Sold	Unit Inven tory	Revision Date	Age Dec.31	MTBF	Pfmn Coord	Size Coord	Price	Material Cost	Labor Cost	Contr. Marg.	2nd Shift & Over-time	Auto mation Next Round	Capacity Next Round	Plant Utiliz.
Able	Low	2,199	381	1/15/2025	2.4	20000	8.7	11.3	$33.00	$11.37	$5.48	46%	79%	7.0	1,300	177%
Andy	High	374	0	7/9/2025	0.5	22000	10.2	9.8	$43.00	$14.34	$9.11	45%	100%	4.5	800	94%
Baker	Low	1,931	297	7/22/2025	1.7	18800	8.7	13.1	$29.10	$10.94	$6.75	37%	33%	7.5	1,400	132%
Bold	High	1,603	239	4/10/2025	1.6	22400	10.3	8.6	$41.90	$17.33	$11.27	30%	74%	4.0	1,150	172%
Best		0	0	3/9/2026	0.0	0	0.0	0.0	$0.00	$0.00	$0.00	0%	0%	4.5	450	0%
Cake	Low	727	1,020	1/29/2022	6.9	19000	6.7	13.0	$30.00	$9.08	$9.90	22%	0%	4.0	1,300	76%
Cedar	Low	623	223	1/15/2022	4.4	19000	9.0	11.0	$40.00	$12.99	$9.90	38%	0%	4.0	700	71%
Candy	High	637	56	2/28/2024	1.8	19000	9.3	11.0	$42.00	$13.26	$11.25	40%	40%	4.0	700	139%
Coffee		0	0	3/8/2026	0.0	0	0.0	0.0	$0.00	$0.00	$0.00	0%	0%	3.0	200	0%
Daze	Low	1,579	5	5/16/2024	3.4	19000	7.3	12.7	$35.50	$9.24	$9.46	46%	100%	5.0	800	198%
Dabble	Low	798	316	2/22/2021	4.9	18000	6.0	14.0	$34.00	$6.74	$9.53	48%	47%	5.0	750	145%
Dude	High	298	681	9/12/2022	3.3	21000	9.1	10.9	$45.00	$12.86	$7.63	33%	0%	5.0	550	90%
Donkey	High	422	0	4/15/2025	0.7	22000	10.1	9.8	$49.00	$14.92	$11.03	46%	100%	5.0	300	141%
Eat	Low	1,123	0	7/21/2025	2.8	18000	8.0	12.0	$30.25	$10.86	$11.32	33%	0%	3.0	700	96%
Egg	Low	693	0	1/11/2025	2.4	21000	7.4	13.3	$35.00	$10.09	$13.04	33%	100%	3.5	1,050	198%
Elk		0	0	9/28/2026	0.0	0	0.0	0.0	$0.00	$0.00	$0.00	0%	0%	1.0	500	0%
Fast	High	891	0	3/18/2025	2.0	21700	9.8	11.3	$41.00	$14.32	$12.03	35%	80%	4.0	500	178%
Faster	High	794	0	3/11/2025	1.7	22000	10.0	11.5	$43.00	$14.46	$13.24	34%	54%	3.0	400	153%
Fasttt	High	687	89	4/14/2025	1.3	23000	10.5	11.8	$46.00	$15.10	$15.80	32%	100%	2.0	300	198%

computer teams follow a prescribed strategy but make some decisions based on results of the ongoing game. Capsim uses equations to determine the decisions for the computer teams based on supply and demand (Langen, 2019).

An example of this decision making is shown in figures 1 and 2. These figures are results from a class capsim simulation played at a large southern university. The class was divided into two groups (F110600 and F111424) with two computer teams (A and B) and four student teams (B, C, D, and F) each. As can be seen in figures 1 and 2, the two computer teams develop the same products (name, segment, age, quality, performance coordinates, and price) for both groups.

However, the two computer teams produce and sell different quantities based on what the four student teams have done. The Group 1 A and B computer teams produce and sell less of the A and B products than the Group 2 A and B computer teams. This is because the combined Group 1 student teams (C, D, E, and F) have produced and sold more total products than the combined Group 2 student teams. The computer teams are programmed to increase or decrease production based on what the student teams have done so that there are not total stock-outs and overpricing.

The current computer teams can be programmed as beginner, average, or advanced depending on how proficient the professor wants the computer teams to be. This forces the student teams to make better sales and production forecasts if they are to beat the computer teams. However, by using AI, the computer teams could be much more proficient. With AI, the computer teams could develop more and different quality products depending on what the student teams have done. This would force the student teams to evaluate not only the quantity of the computer team's products but also the variety and quality of the computer team's products. The computer teams would play more like "expert" student team with no prescribed strategy.

The degree of sophistication of the latest equation-based demand models for business simulations is remarkable. Nevertheless, such types of models usually make use of mean values of simulation parameters and neglect the dynamics of the micro -level interactions. For instance, to calculate market demand, equation-based simulations usually resort to the mean values of the firms' decisions for marketing and R&D expenditures as well as price. Moreover, demand equations lack the ability to mimic in detail the complex interactions which may occur between consumers such as processes of product qualification/disqualification and word-of-mouth. Agent-based modeling, in contrast with the equation based approach, takes a bottom-up approach to the simulation of systems. Instead of describing the relationships between the modeled entities through the use of equations, agent-based modeling prescribes the individual behavior of the micro-level entities and their interaction rules (Baptista et al, (2014).

Rich agent-based data concerning the intentions, beliefs, desires of consumers as well as their complex interactions can profoundly reshape business simulations. This approach can allow more transparent simulations, which can become more complex, reaching exceptional levels of realism and sophistication, without sacrificing the successful learning experience of participant. Capsim is investigating such agents for their computer teams that are required in some of their simulations (Langen, 2019).

Revas

Revas Simulations is a start-up simulation firm in Poland. They focus on high school as well as universities. Their simulations enable students to **experience business** by running a virtual small company. This is a new experience for much of the Polish population. Participants make **realistic managerial decisions** such as designing the offer, hiring, setting prices, purchasing supplies etc. in order to train **business acumen, decision making, problem solving, planning, teamwork -** and to realize if they have what it takes to be a manager. Students can **experiment with business strategies** in a **risk-free environment** in 1 of **10 available simulations in industries such as a travel agencies, car repair shops, and beauty salons (**www.revas.pl, 2019)**.**

Currently, Revas algorithms are based on multi-criteria equations to ensure both realism and playability. The most sophisticated algorithms were designed for demand distribution and sales. The first one is a multi-criteria and adaptive function that distributes market demand between teams within pre-defined constraints that adapt to the market situation created by the players. Sales algorithm allocates resources iteratively to make sure that supply is distributed evenly among all services/products in the team's portfolio. In the simulations where play is against computer-generated competitors, they use pre-defined scenarios with probability function and algorithms to adjust the game difficulty level to the player's level.

Revas is researching how to introduce AI to their future simulations especially in the field of player's evaluation. Multi-criteria algorithms would then be able to evaluate players against their teammates but could also look for similar data sets to compare with the whole populations of players (Szczepaniak, 2019).

Racing Game

Podgorski and Wardaszko (2019) presented conceptual work for the construction of a next generation racing game at the 2019 ISAGA conference in Poland. The main innovation of their product was the realism of the driving experience and the use of machine learning to improve the simulation. The machine learning component was intended for two purposes – as a map for detailing elements and for setting the parameters of objects in the game.

SUMMARY

Using AI has been one of the desires of engineering and computer science since the 1950's. However, the use of AI has had ups and downs depending on the success of AI applications. Today, due to advances in computer power, large amounts of data, and improved programming languages, AI is being used in many applications. A similar experience can be seen in the use of AI for business simulations. AI has been on the wish list of business simulation for many years but with little actual use. Today, however, AI seems to be breaking through with potential applications in many simulations, both in long established firms and new start-up firms, both in the US and around the world.

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