



Tepper School's Intellectual Contributions in **OPERATIONS RESEARCH** and Related Areas

THE INTELLIGENT FUTURE

21 MARCH 2025

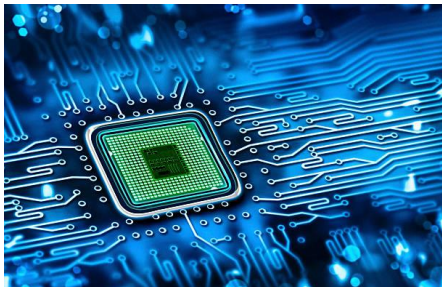
John Hooker

Carnegie Mellon University
Tepper School of Business

OPERATIONS RESEARCH



- **OR runs our modern world.**
- Design, manufacturing, transportation, computing, telecom, agriculture, finance, healthcare, etc. etc.
 - e.g., global supply chain (largest human artifact)



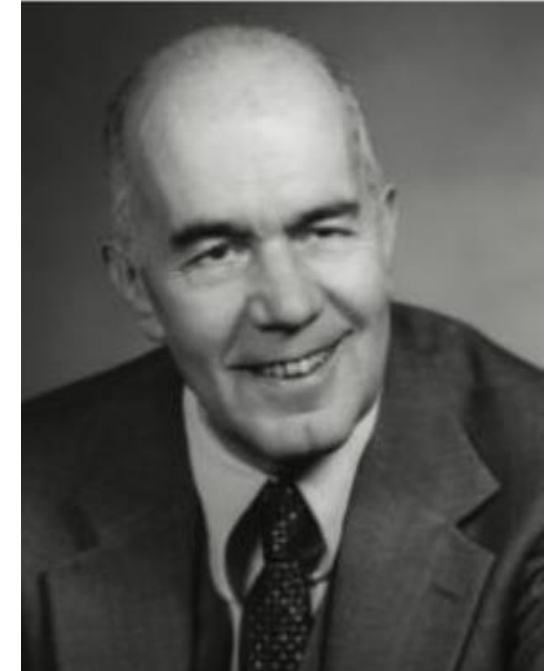
OPERATIONS RESEARCH



- Where did it start?
**HERE! The birthplace
of industrial OR.**



Abraham Charnes
1917-1992

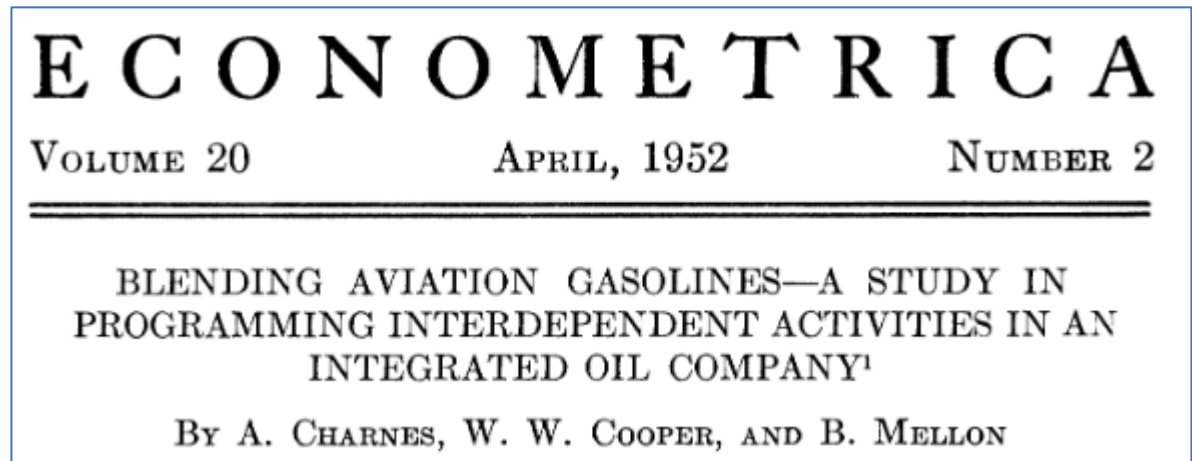


William Cooper
1914-2012



FIRST INDUSTRIAL APPLICATION

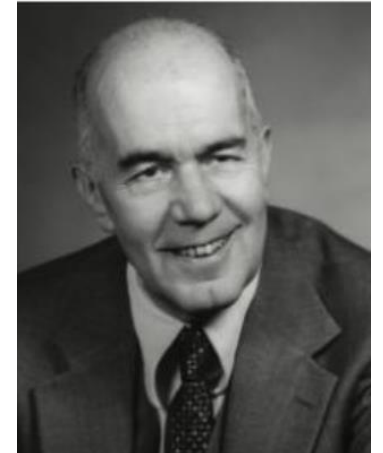
- **First full-scale industrial application of OR**
 - Linear programming model of a Gulf Oil refinery
- **First optimization model solved by computer.**
 - Charnes, Cooper, and Bob Mellon of Gulf Oil reworked George Dantzig's simplex method for computer solution.





CHARNES & COOPER

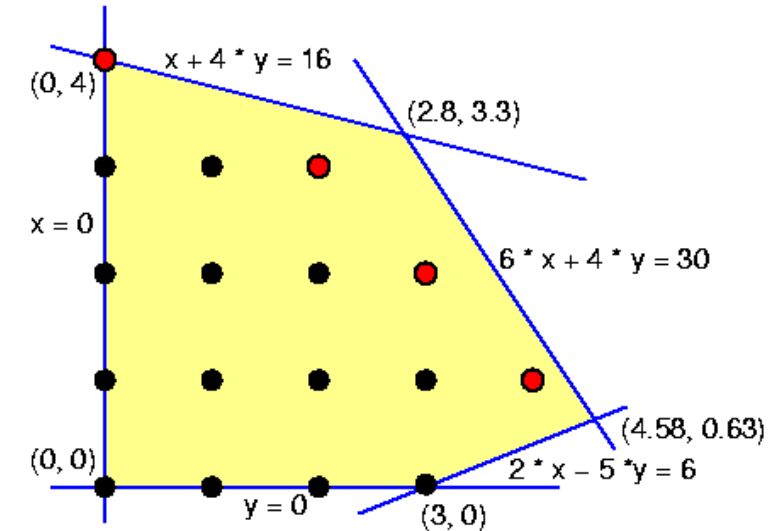
- 40-year collaboration, focus on **industrial applications**.
- Methodological contributions:
 - Data envelopment analysis
 - Multiobjective programming
 - Linear fractional programming, etc.
- Cooper: “**Father of management science.**”
 - Founder of Heinz School



INTEGER PROGRAMMING



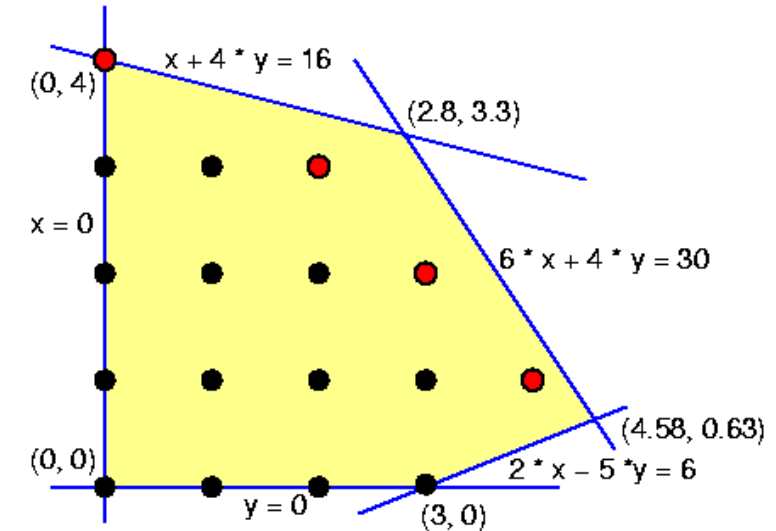
- Generalization of linear programming with **far more applications**.
- Integer programming raises two key questions:
 - 1. **What problems** can one model with it?
 - 2. How to **solve** it?





INTEGER PROGRAMMING

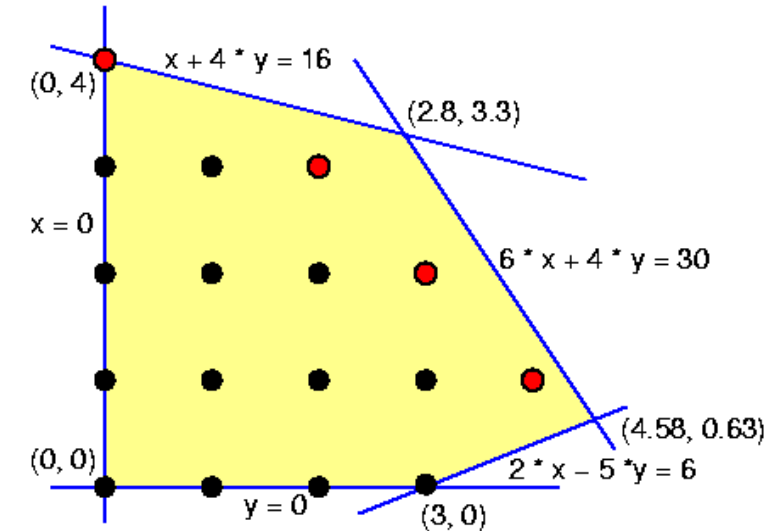
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- Question 1: Answered **HERE!**





INTEGER PROGRAMMING

- Generalization of linear programming with **far more applications**.
- Integer programming raises two key questions:
 - 1. **What problems** can one model with it?
 - 2. How to **solve** it?
- Question 1: Answered **HERE!**
- Question 2: To a large extent, answered **HERE!**





INTEGER PROGRAMMING

- Robert Jeroslow: complete conditions for when a problem has an integer programming **model**.
- Egon Balas: theoretical contributions that led to major advances in **solution methods**.
- Both used disjunctive programming.



Robert Jeroslow
1942-1988



Egon Balas
1922-2019

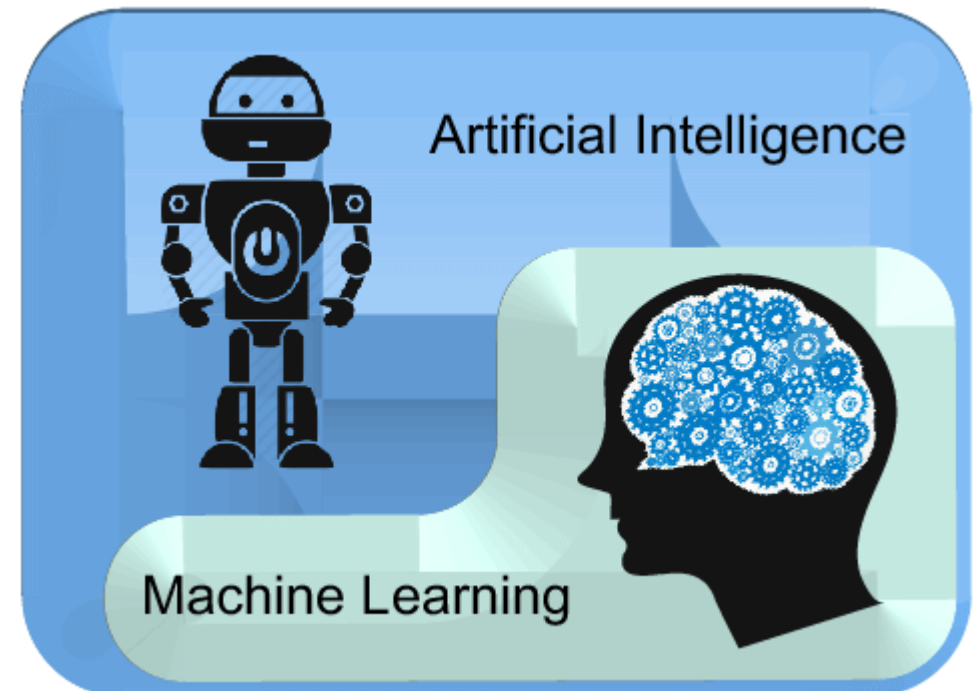


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ARTIFICIAL INTELLIGENCE

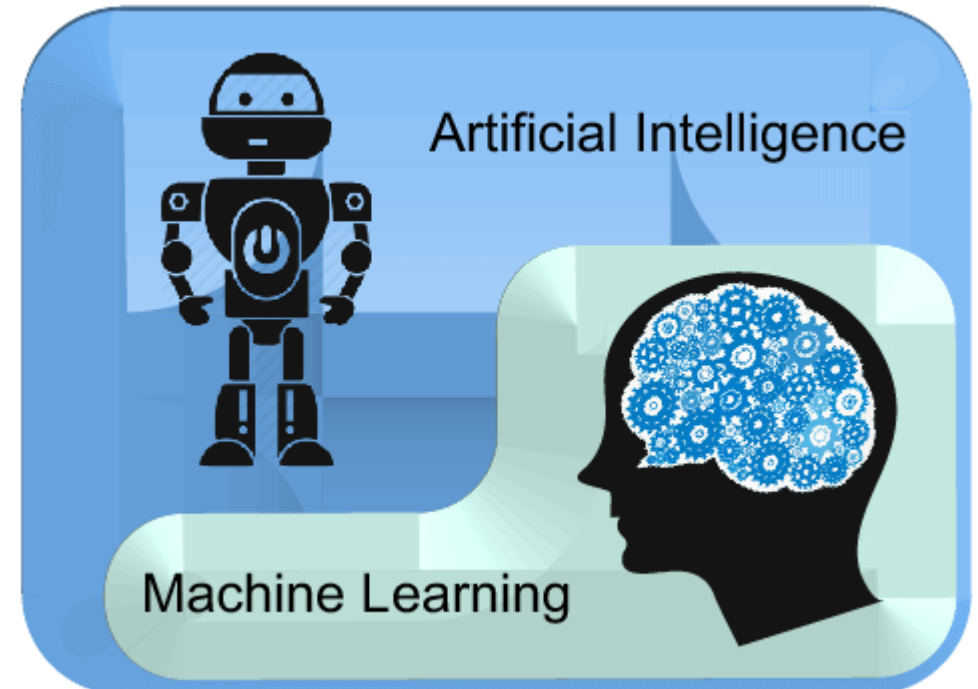
- A **rapidly expanding** technology today.
- Inseparable from operations research.
 - Current research frontier is **OR/ML integration**.





ARTIFICIAL INTELLIGENCE

- A **rapidly expanding** technology today.
- Inseparable from operations research.
 - Current research frontier is **OR/ML integration**.
- Where did it start? **HERE!**
 - GSIA was the **birthplace of AI**.



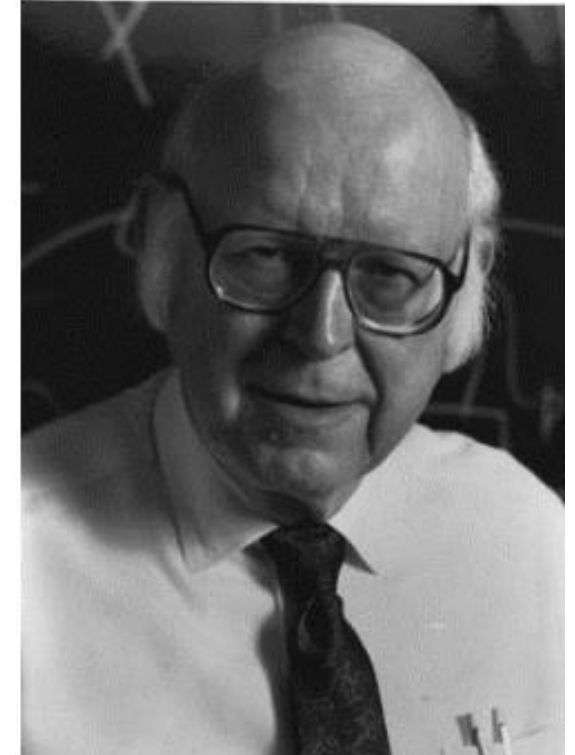
ARTIFICIAL INTELLIGENCE



- Simon & Newell (with Cliff Shaw of RAND) created the **first AI programs**.
 - Logic Theorist (1956)
 - General Problem Solver (1957)
- Newell was Simon's PhD student at GSIA.



Herbert Simon
1916-2001



Allen Newell
1927-1992



COMPUTER SCIENCE

- CMU computer science got its start... where? **HERE!**
 - The CS Department came a decade later.



Herbert Simon



Alan Perlis
1922-1990



COMPUTER SCIENCE

- CMU computer science got its start... where? **HERE!**
 - The CS Department came a decade later.
- Herb Simon and Alan Perlis established first computer center in basement of GSIA (1956).
 - With Newell, credited with coining the term "**computer science**."
 - All three received Turing Awards.
- Invented **linked lists**, an essential element of programming languages.



Herbert Simon



Alan Perlis
1922-1990



OUR PHD STUDENTS

- Distinguished positions worldwide in both academics and industry.
- Leaders in today's OR profession
 - For example, current **Chair** of INFORMS Computing Society
 - **Chair** of ICS Conference (met last week)
 - 2020 **President** of INFORMS, etc.
- Current students sponsor **Yinz OR** and its annual conference.



INFORMS = Institute for Operations Research and the Management Sciences, flagship U.S. professional organization for OR/MS.



ONGOING OR RESEARCH STREAMS

- **Machine learning and optimization**
- Polyhedral theory and cutting planes
- Combinatorial optimization
- Convex optimization
- Semidefinite programming
- Stochastic optimization
- Graph theory
- Constraint programming
- Logic-based optimization
- Decision diagrams
- Ethical algorithm design
- Fairness modeling
- Quantum computing



SOME ONGOING OR/OM APPLICATION AREAS

Operations management:

- Supply chain logistics
- Inventory management
- Product design & development
- Revenue management
- Online marketing
- Manufacturing operations
- Renewable energy
- Autonomous vehicles

Healthcare related:

- Transplant management
- Transplant fairness
- Home health care
- Child welfare
- Vaccine delivery
- Healthcare investment
- Drug price forecasting
- Healthcare supply chain



BUSINESS ETHICS

Tom Kerr: A pioneer in business ethics

- Introduced the topic to GSIA on arrival in 1965.
 - Business ethics as a field came **later** (1974).
- Today: 5 faculty members in behavioral and normative ethics.
 - Taking a uniquely **analytical** approach.

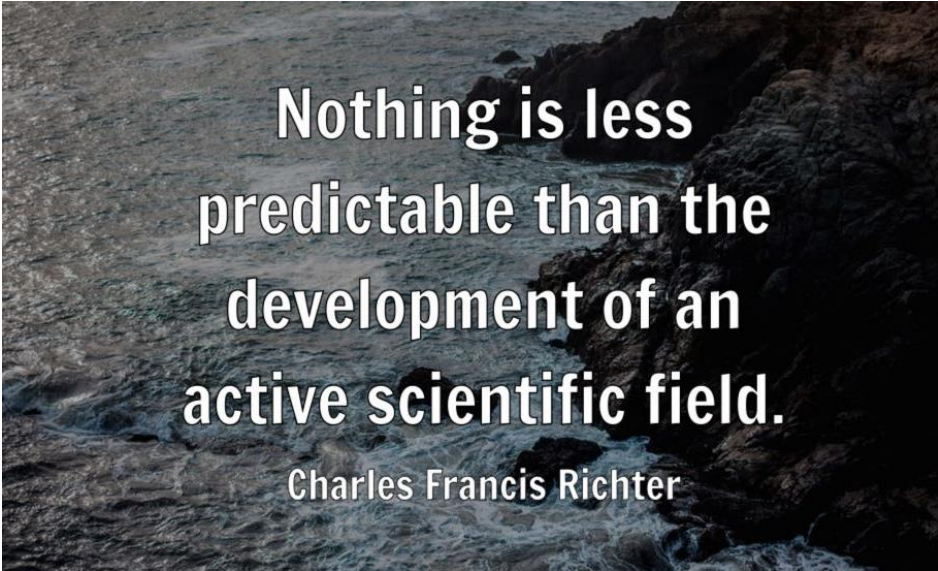


Thomas M. Kerr
1919-2006



THE FUTURE?

- The world-changing research described here required **decades** to reach full potential.
- No one can predict where **today's research** will lead.



Nothing is less
predictable than the
development of an
active scientific field.

Charles Francis Richter