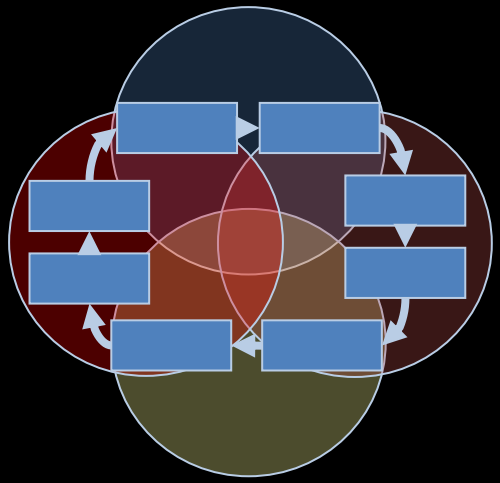
Cognitive Analytics and Evidence-Based Decision Making

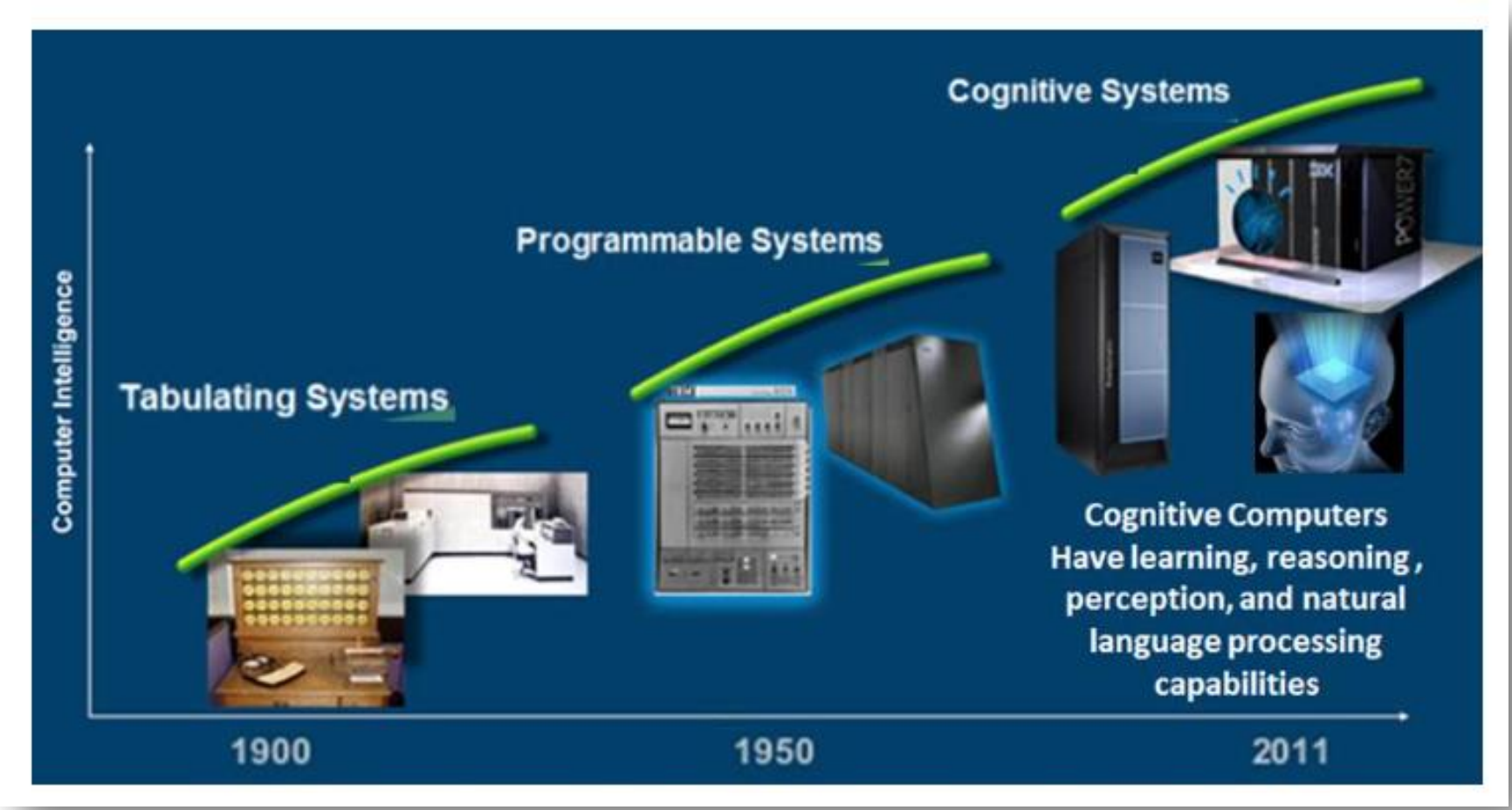


Dr. Chris Asakiewicz

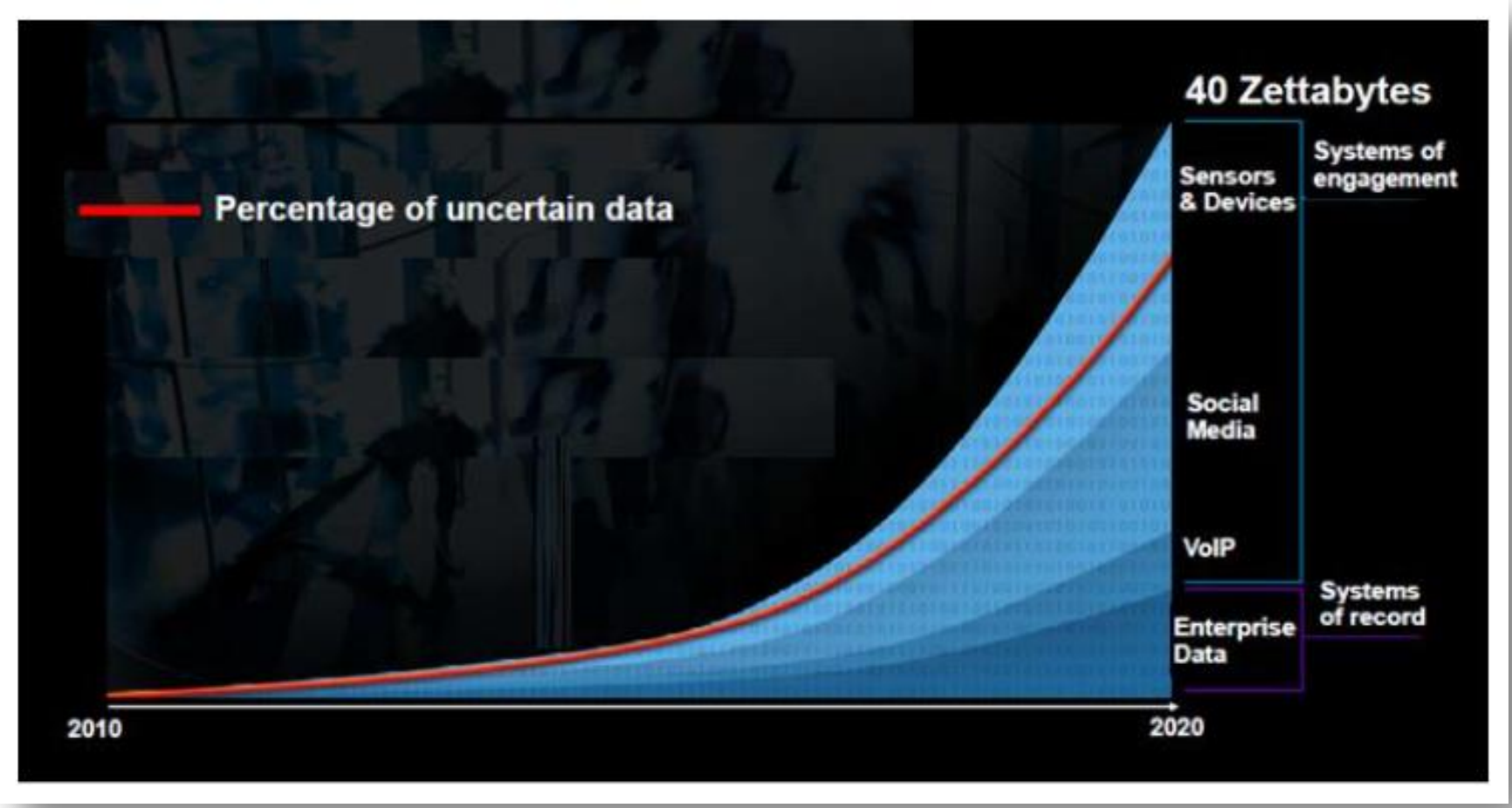
Stevens Institute of Technology

School of Business

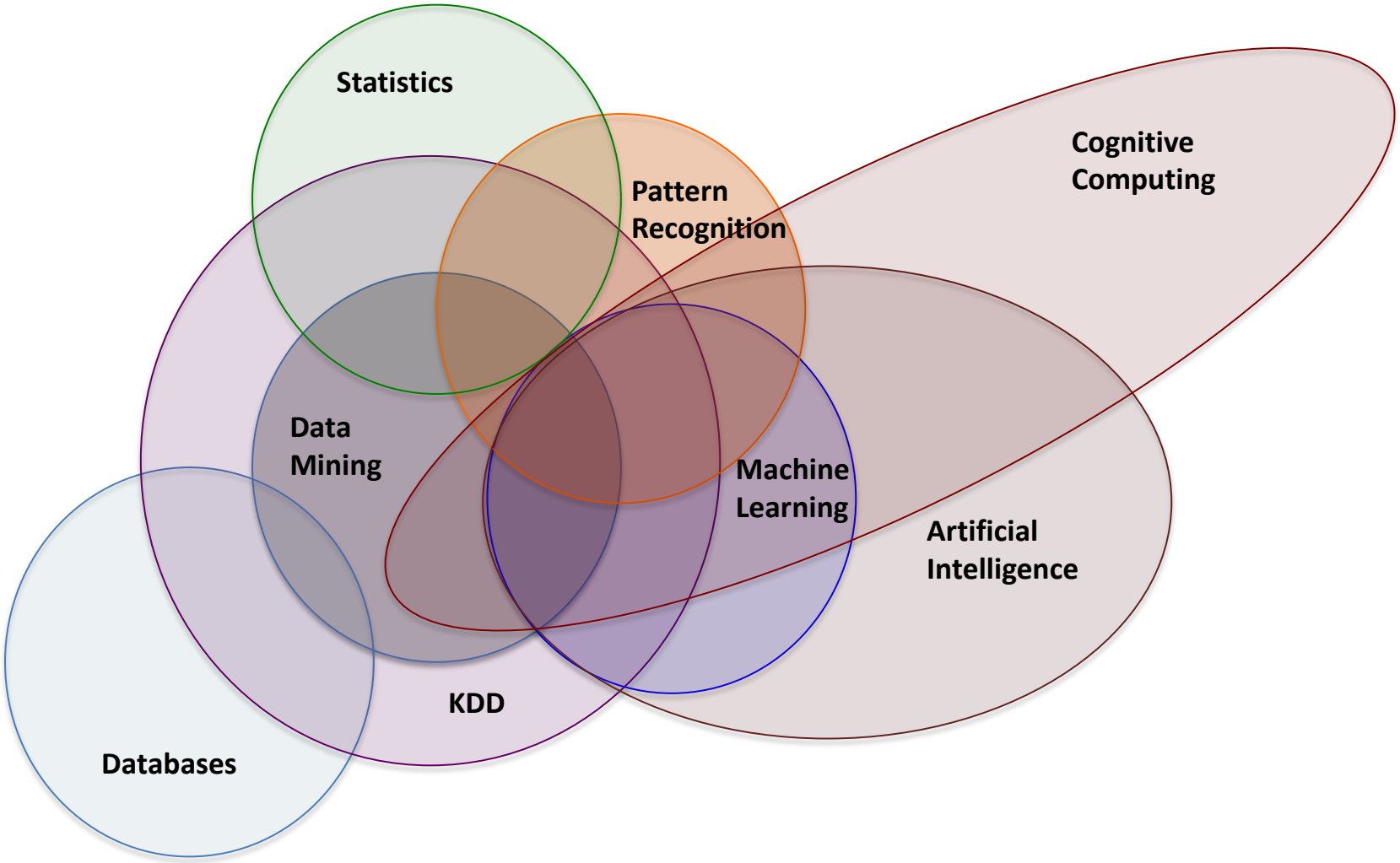
Evolution of Computing Systems



Impact of Big Data



Machine Intelligence



Cognitive Computing Systems

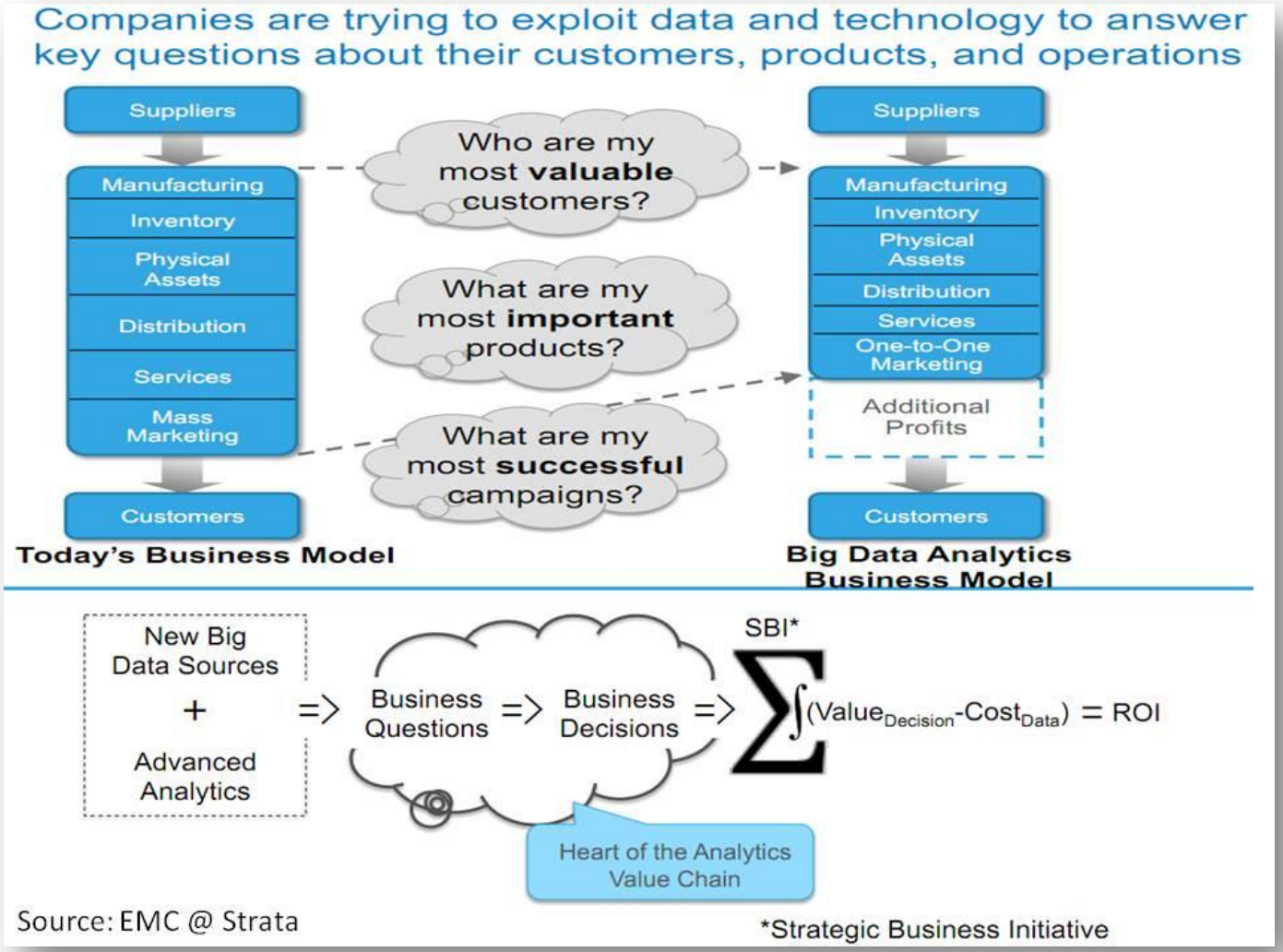
- **Cognitive computing systems redefine the nature of the relationship between people and their increasingly pervasive digital environment. They may play the role of assistant or coach for the user, and they may act virtually autonomously in many problem-solving situations. The boundaries of the processes and domains these systems will affect are still elastic and emergent. Their output may be prescriptive, suggestive, instructive, or simply entertaining.**

- **In order to achieve this new level of computing, cognitive systems must be:**

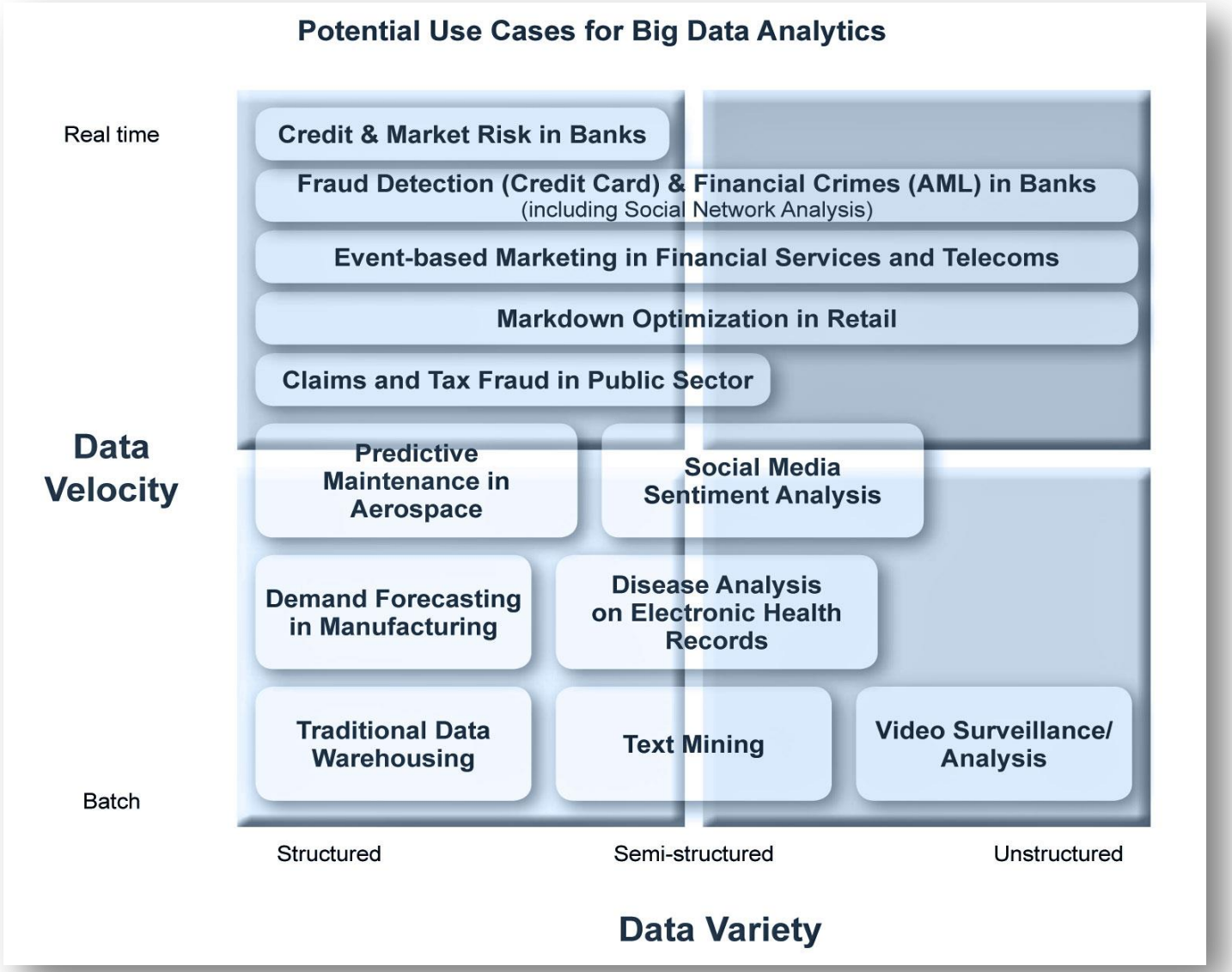
  - ***Adaptive:*** **They must learn as information changes, and as goals and requirements evolve. They must resolve ambiguity and tolerate unpredictability. They must be engineered to feed on dynamic data in real time, or near real time.**
  - ***Interactive:*** **They must interact easily with users so that those users can define their needs comfortably. They may also interact with other processors, devices, and Cloud services, as well as with people.**
  - ***Iterative and stateful:*** **They must aid in defining a problem by asking questions or finding additional source input if a problem statement is ambiguous or incomplete. They must "remember" previous interactions in a process and return information that is suitable for the specific application at that point in time.**
  - ***Contextual:*** **They must understand, identify, and extract contextual elements such as meaning, syntax, time, location, appropriate domain, regulations, user's profile, process, task and goal. They may draw on multiple sources of information, including both structured and unstructured digital information, as well as sensory inputs (visual, gestural, auditory, or sensor-provided).**

Wikipedia

Searching for Answers

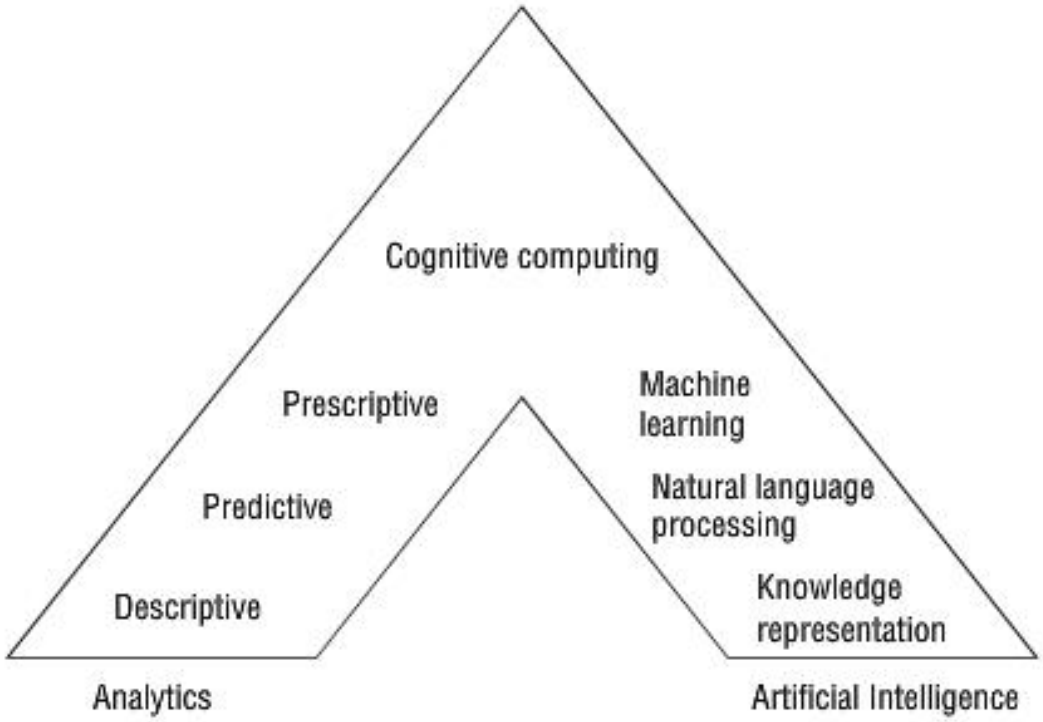


Decision Making Areas

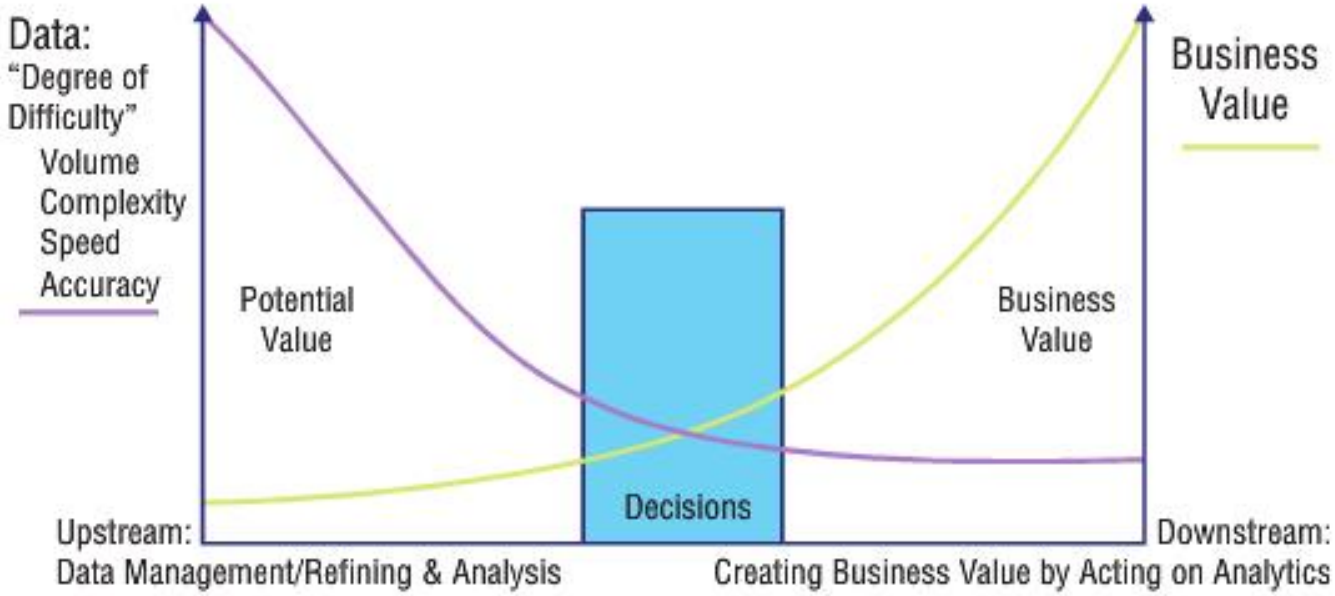


Advanced Analytics

Converging Technologies

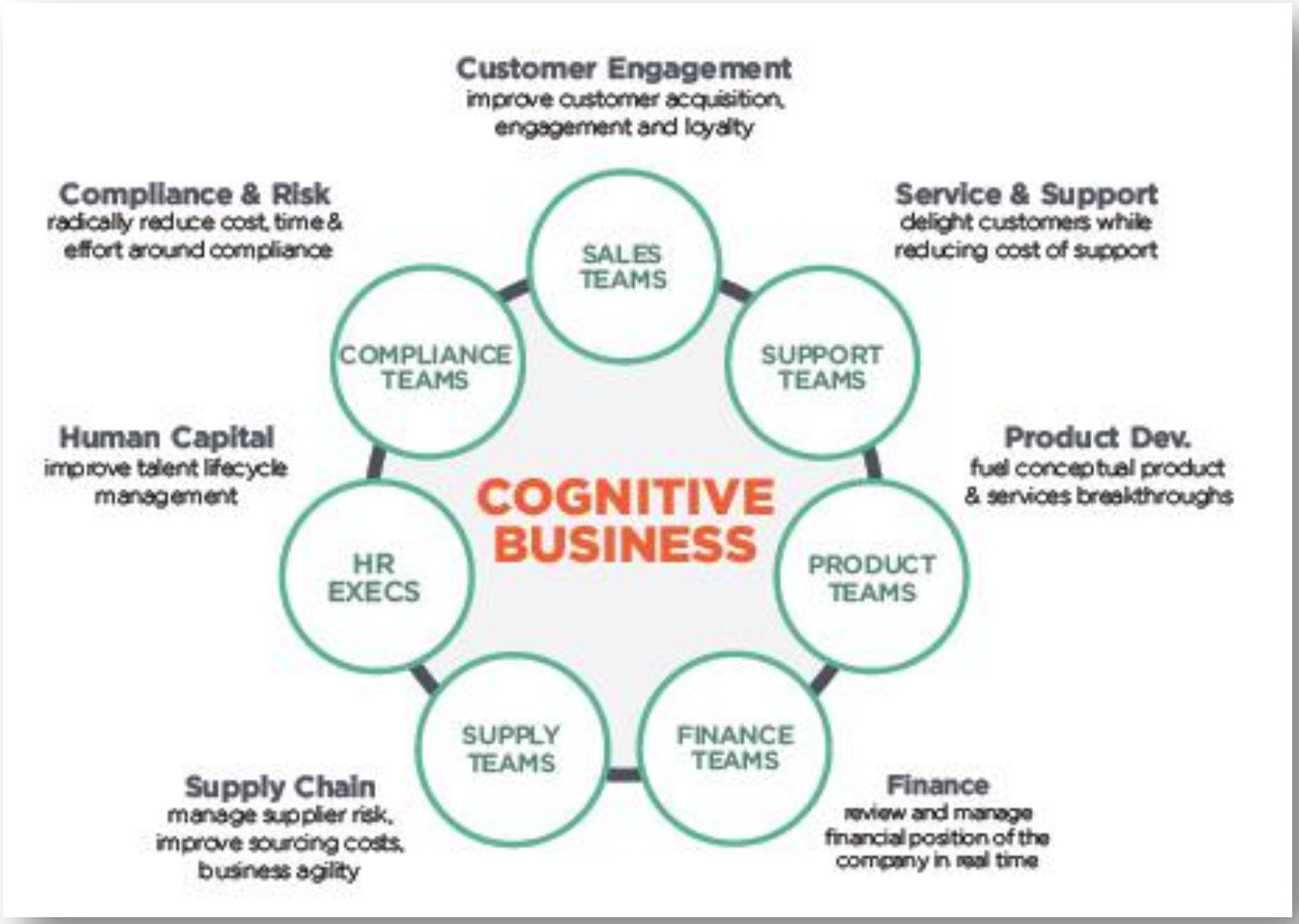


Advanced Analytics

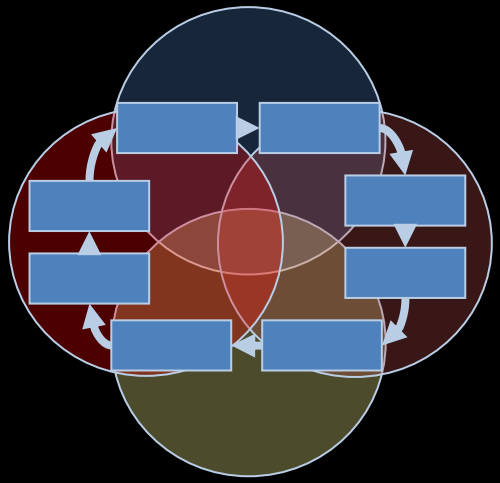


Raw Data to Business Value

Augmented Intelligence



Cognitive Analytics and Evidence-Based Decision Making



FRAMEWORK

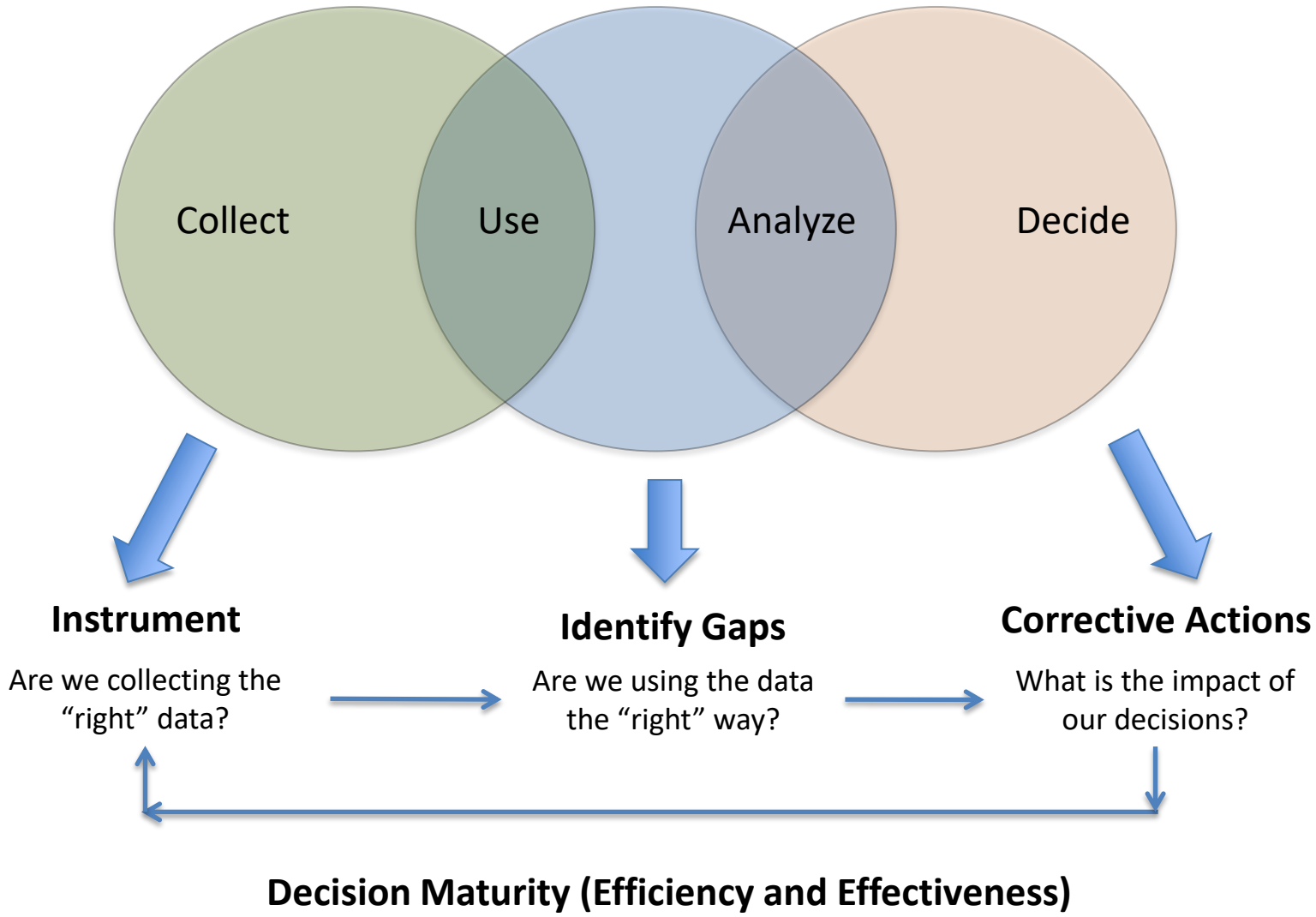
Dr. Chris Asakiewicz

Evidence-Based Decision Making[1]

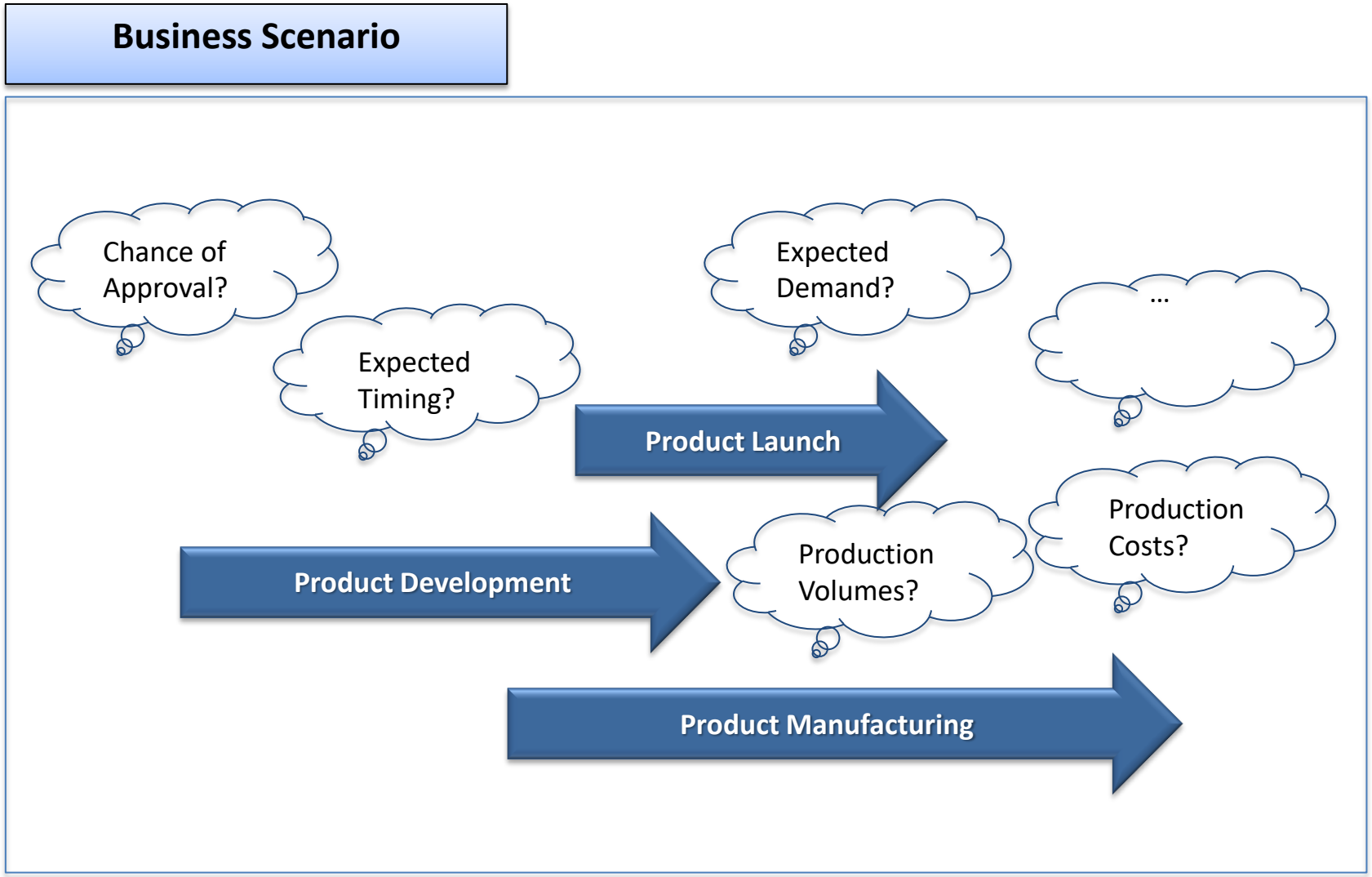
Artifact	Past	Present	Future
Information	What Happened?	What is Happening?	What Will Happen?
Mechanism	Reporting	Alerts	Extrapolation
Tool	Modeling and Experimental Design	Recommendations	Prediction, Optimization, and Simulation
Insight	How and Why Did It Happen?	What is the Next Best Action?	What is the Best/Worst That Can Happen?

[1] Thomas Davenport, et.al. (2010) Analytics at Work. Harvard Business School Press. Boston Mass. ISBN:978-1-4221-7769-3.

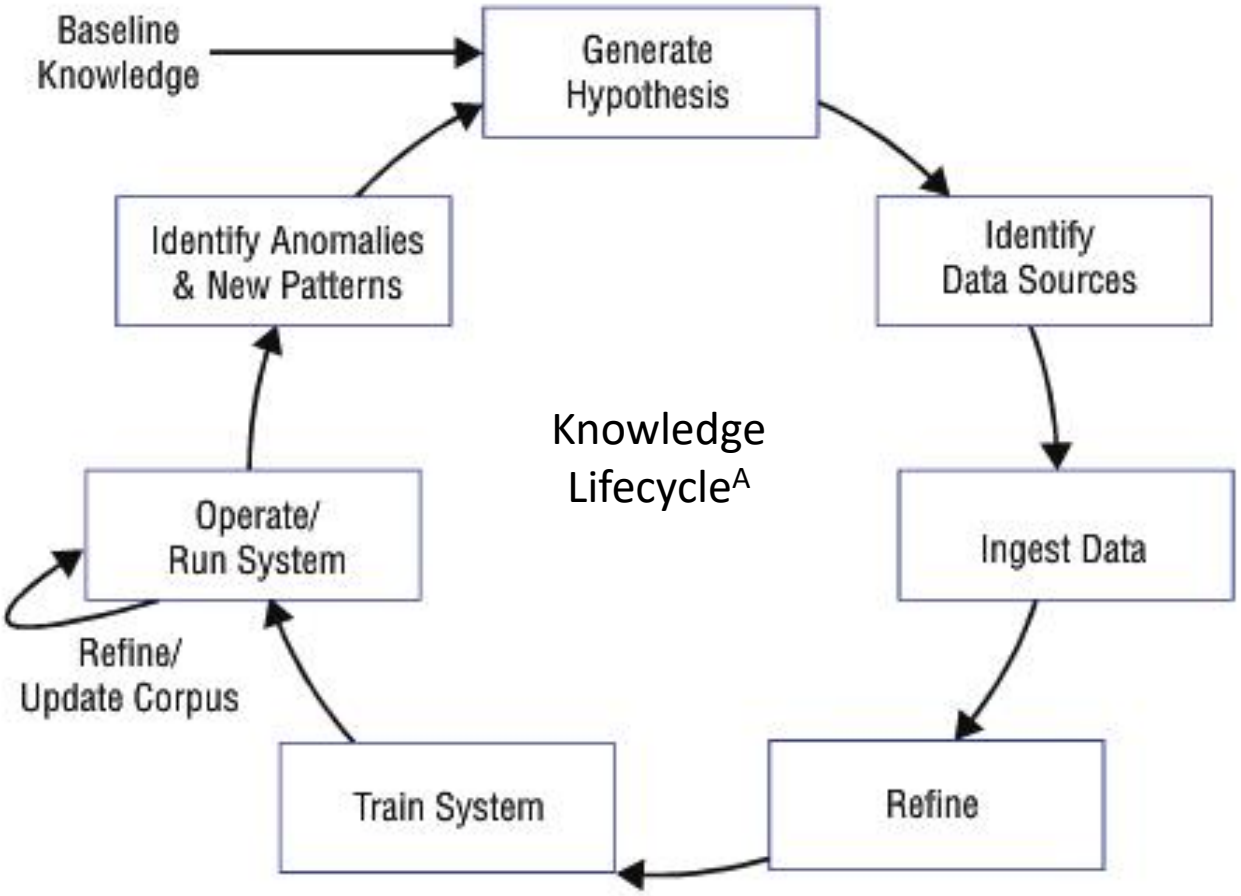
Evidence Based Decision Framework



Asking the “Right” Questions



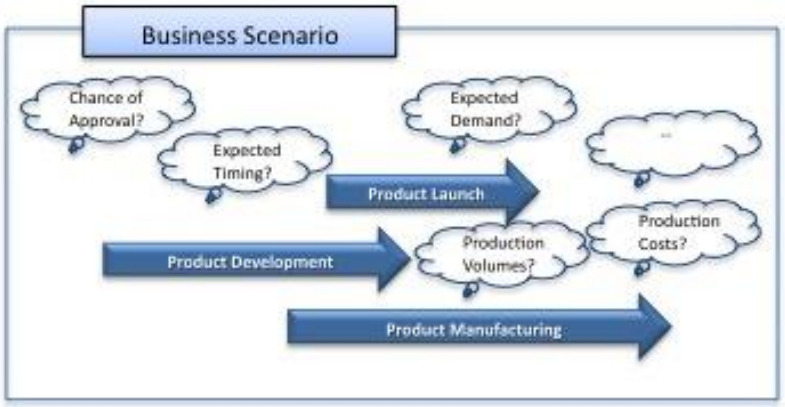
Asking the “Right” Questions

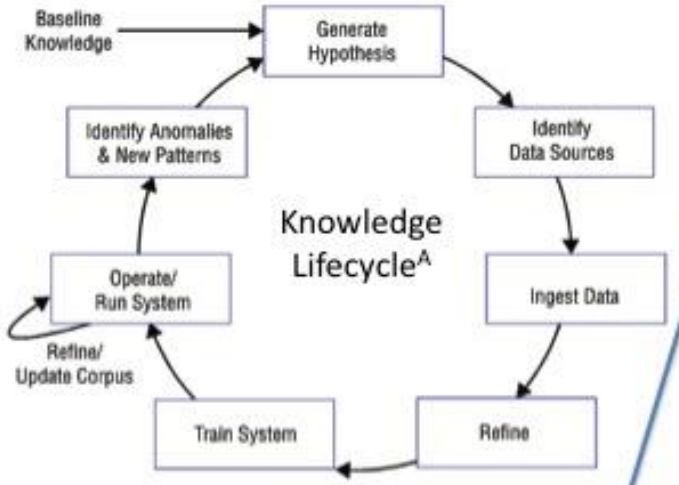


[A] J. Hurwitz, et.al. – Cognitive Computing and Big Data Analytics – 2015 Wiley

Cognitive Analytics Framework

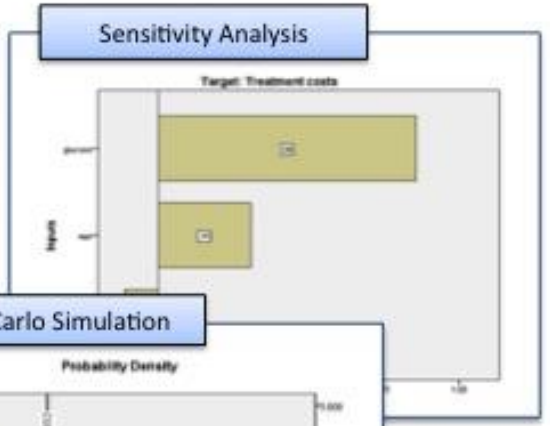
Asking the "Right" Questions

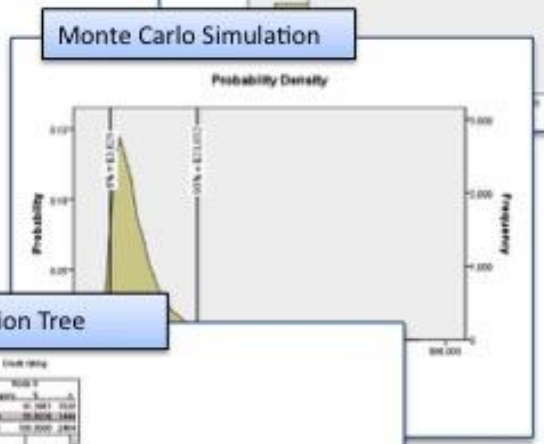


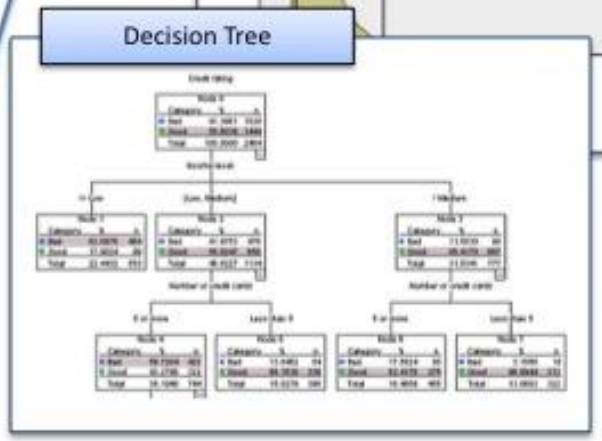


[A] J. Hurwitz, et.al. – Cognitive Computing and Big Data Analytics – 2015 Wiley

Searching for the "Right" Answers







Decision Variables
- Opportunities
- Funding Types
- Customer Categories
- Competencies
- Proposal Status
- Resource Feasibility
- Technical Feasibility
- Capability Increase
- Risk Level
- Commitment

Cognitive Projects

Cognitive Stock Prediction Web-based Application

Saud Almahdi, Jeffrey Mo

STEVENS INSTITUTE of TECHNOLOGY — THE INNOVATION UNIVERSITY

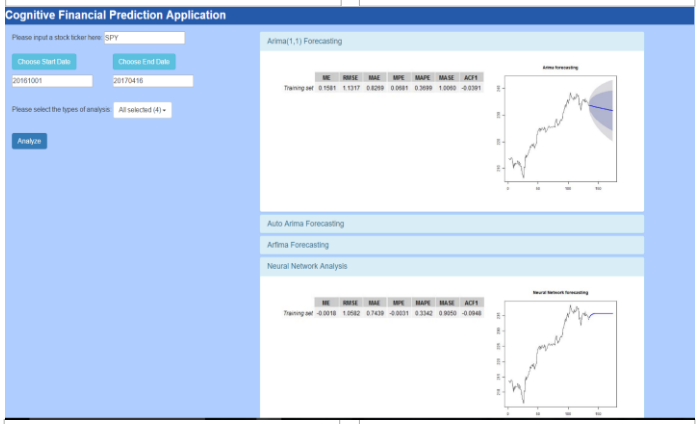
Business Intelligence & Analytics

Introduction

- There has been an increasing attention to the stock market forecasting models. Due to the big amounts of data available that can be implemented to train and test these models. Using the historical stock prices we can develop many forecasting models that can fit the data and predict the next direction of the stock with different accuracies in a user friendly environment.

Results

- Forecasting analysis based on 4 different models providing different views of the predicted stock price.
- The user will be able to decide which model fits his stock choice and time frame better by looking at the accuracy measure for each model.
- A user friendly environment with an automatic fetching of the data to be analyzed.



Methods

Business Question

- What is the next decision the investor should take?

Data & Scope

- Historical data fetched automatically from Yahoo finance to compare different forecasting models

Architectural Approach

- HTML, CSS, Jquery, and PHP Web Programming
- R Programming for Data Fetching and Analysis

Conclusion

- Every machine learning and statistical model performance is based on the data to be analyzed. This web based system can provide four different models for the investor to look at and decide which model fits the best in order to develop an accurate forecast.
- The next step would be to add a decision support system that would suggest a trading rule based on the forecast and taking into consideration the investor's position in the market and goal.

http://www.stevens.edu/school-business/masters-programs/business-intelligence-analytics

Intelligent Academic Advisor

Abhinav Panwar, Piyush Bhattad, Vaibhav Desai, Deepanshu Tyagi
Instructor: Christopher Asakiewicz, Edward Stohr

STEVENS INSTITUTE of TECHNOLOGY — THE INNOVATION UNIVERSITY

Business Intelligence & Analytics

Introduction

- The BI&A program receives hundreds of questions from potential applicants, including many frequently and some infrequently asked questions. Engaging the interest of potential applicants can be very important in both differentiating our program and ensuring that interest eventually turns into applications.
- The Intelligent Academic Advisor is a Watson-based question answering (QA) cognitive computing system. The system utilizes advanced natural language processing, information retrieval, automated reasoning, and machine learning algorithm to provide answers to program related questions.

Performance

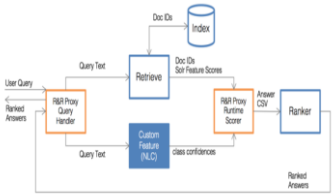
Data

- The source of information for the application includes an initial corpus of 292 questions and answers covering 15 topic areas.

Results

- The Intelligent Academic Advisor application will help potential applicants find answers to their questions. It will help differentiate our program and will potentially turn interest into applications.
- After the classifier is integrated with Rank and Retrieve service, the ranker can be trained on a corpus of frequently asked question, and then combining score from retrieve and classification to increase the confidence of response to infrequently asked question by user.

Architecture



This system consists of two Watson Services:

❑ **Rank & Retrieve (R&R):**
- Used to identify the most relevant answer to the question asked by the user.
- Built on top of Apache Solr and returns a set of results based on a combination of search and machine learning algorithms.
- Based on response confidence the highest ranking response is provided as an answer to the question.

❑ **Natural Language Classifier (NLC):**
- Used to better understand the "context" of the question being asked by the user.
- Classifies the questions related to Stevens, based on categories like location, skills, BI&A program etc.

Future Work

- This initial application demonstrates the power of a cognitive assistant in helping to find answers to frequently, and not so frequently asked questions. Turning interest into applications has a significant benefit to the school as well as to the potential applicant (by saving time, reducing frustration, and helping match the interests of our audience with our offerings). If successful the application can be expanded from the BI&A Program, to the School of Business, and ultimately to Stevens.
- The Intelligent Academic Advisor can be deployed using Watson Conversation service, which can be integrated with Natural language classifier and Rank and Retrieve service in the backend. The front end of Watson Conversation service can be integrated with Text-to-Speech and Speech-to-Text service to provide cognitive interface to end user just like Apple Siri.

http://www.stevens.edu/school-business/masters-programs/business-intelligence-analytics

Cognitive Projects

Stock Trend Prediction by TensorFlow

Peng Dong

STEVENS INSTITUTE of TECHNOLOGY — THE INNOVATION UNIVERSITY — Business Intelligence & Analytics

Introduction

Stock trend prediction is always a hot spot in financial field. Fundamental analysis and quantitative analysis have been used through time.

In this project, I use financial and sentiment data predict stock price for a certain ticker.

Researches for this project is mainly focus on:

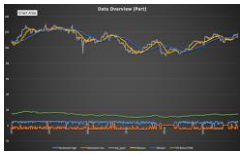
- Which model is better at stock trend prediction?
- What is the suitable data structure and time frame for stock trend prediction?
- Does sentiment data make difference in the model?

Data

Data Source:

- Stock price data is collected from Quandl.com
- Ratio data is collected from YCharts.com
- Sentiment data is collected from Infotrie

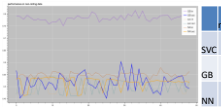
Data Overview:



Data Structure:

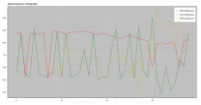
Non-rolling data rolling data

Results



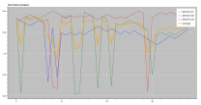
	mean	high	std
SVC	50.14 %	54.26%	2.98%
GB	51.83 %	60.29%	3.37%
NN	51.83 %	54.02%	2.32%

* Based on non-rolling data, GB has the best overall performance. NN is most stable



	mean	high	std
SVC	48.74 %	56.11%	3.36%
GB	49.91 %	57.27%	2.78%
NN	52.45 %	54.02%	1.91%

* Based on rolling data, NN out-performs the other two models



	2 days	5 days
22 days ~ 28 days		

*As the testing set changing, time frame with [2~6]&[22~28] has the best performance

	mean	high	std
SVC	50.14 %	54.26%	2.98 %
GB	51.83 %	60.29%	3.37 %
NN	51.83 %	54.02%	2.32 %

	mean	high	std
SVC	50.57 %	55.17%	2.94%
GB	52.21 %	59.35%	3.98%
NN	51.90 %	53.88%	2.26%

*Sentiment data makes no difference in these models.

Conclusion

- Only GB can fit the training set well
- Based on testing data, all the models perform bad (slightly better than flipping coins)
- The best model is the one trained by NN and based on rolling data
- Sentiment does not perform a key role in the stock trend prediction

http://www.stevens.edu/school-business/masters-programs/business-intelligence-analytics

Facial Expression Recognition with Deep Learning

Hanzhuo (Andrew) Li
Instructor: Dr. Christopher Asakiewicz

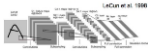
STEVENS INSTITUTE of TECHNOLOGY — THE INNOVATION UNIVERSITY — Business Intelligence & Analytics

Introduction

- "Facial expression is a visible manifestation of the affective state, cognitive activity, intention, personality, and psychopathology of a person; it not only expresses our emotions, but also provides important communicative cues during social interaction" (Lajevardi & Hussain, 2009).
- Deep learning using neural networks have claimed state-of-the-art performances in a wide range of tasks. It has achieved some tremendous progress in the fields of speech and vision recognition, and natural language process.
- Kaggle provided the facial expression dataset. The dataset consists of over 28,000 facial images classified into 7 categories.

Experiment Method

- **Deep learning library**: Google TensorFlow
- **Convolutional neural networks** as feature extractor:
  - Feed-forward:
    - Convolve input
    - Non-linearity (rectified linear)
    - Pooling (local max)
  - Supervised
  - Train convolutional filters by back-propagating classification error

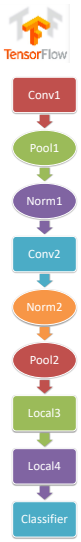


- **Softmax regression** as classifier:

$$\text{softmax}(x)_i = \frac{\exp(x_i)}{\sum_j \exp(x_j)}$$

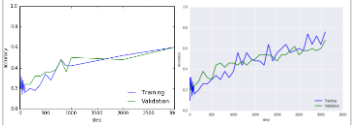
x: input image
i: the class of the input image
j: an index for summing over the pixels in our input image *x*

- The detailed convolutional neural network + soaftmax regression model is showed as right process graph
- Data description:
  Instances: 28,709 48*48 pixel gray-scale images of people faces
  Classes: seven categories of facial expression (Angry, Disgust, Fear, Happy, Sad, Surprise, Neutral)



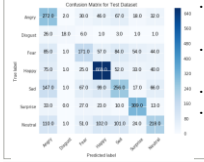
Results

- **Training and validation accuracy**:
  After training the convolutional neural network for almost 4000 times, the train and validation accuracy change trends are showed in below graphs (3000 and 4000 steps)



- **The example input:**

- **Performance of Test dataset:**



- The each number in left confusion matrix shows how many instances with one true label are classified into one predicted label.
- The more number and darker color means that the more instances with one true labels are predicted with same or different label.
- The left-up to right-down diagonal represents accurate predictions.
- **Around 68% prediction accuracy. The best can reach 68%**

Laptop Demo

- **Step 1:Take photo & locate face via camera**
- **Step 2:Output result**

Example 1: Happy

Example 2: Surprise

Conclusions

- Using convolution neural network and softmax regression, this project can achieve around 68% accuracy in training and validation datasets without over-fitting for the 7 categories classification task.
- The model can classify most facial expressions accurately, especially happy. Disgust was the most difficult one to recognize.

http://www.stevens.edu/howe/academics/graduate/business-intelligence-analytics

Cognitive Projects

Murder Accountability Project

Nick Cohron, Olivia Evans, Yiying Hu

STEVENS INSTITUTE of TECHNOLOGY — Business Intelligence & Analytics

Introduction

Background

- Murder Accountability Project[1] (MAP) created to address the decrease in U.S. homicide clearance rate from nearly 90% in the 1960s to less than 60% in 2015
- As discussed in February 8th, 2017 BusinessWeek Article, "Serial Killers Should Fear This Algorithm"
- Data: FBI Uniform Crime Report including 632,455 police reports of murders with 32 factors from 1980 to 2014

Business Problem

- Can more homicides be solved using advanced analytics tools such as IBM Watson or deep learning algorithms on homicide data?
- Can we detect previously unknown serial killers operating across jurisdictional lines?

Methodology

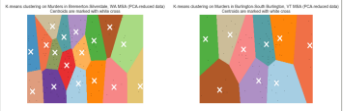
Since the current work being done on the Murder Accountability Project is based on an algorithm that requires the manual review of cases, we wanted to take a more rounded approach in our methodology. Therefore, we took two approaches: a more traditional evaluation and a deep learning evaluation, in an attempt to understand which would be more useful going forward.

Evidence Based Evaluation of Cases

- Find offenders who have same age, sex, ethnicity, race and have been active in same area (based on MSA)
- Narrow down the offenders by excluding some incidents unlikely to be caused by serial killers, i.e., Children Playing with Gun or Motor Vehicle Theft, etc.
- Furthermore, locate cases with similar victim features, such as age, group, gender, race and ethnicity

TensorFlow Clustering

- Clustered using K-means++ across 409 Metropolitan Statistical Areas (MSAs)
- Results in clusters for each MSA, need to evaluate further to identify areas of particular interest



Bremerton-Silverdale, WA Cluster

Burlington-South Burlington, WA Cluster

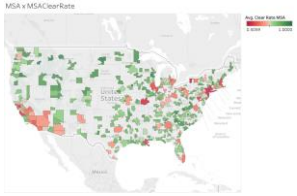
Further Exploration

Link the Methodologies

- For a better evaluation in the future, we are pursuing an optimal algorithm that can have the computational flexibility of TensorFlow, while still evaluating cases based on what domain experts know about serial killers

Evaluate Clusters

- Continue evaluation of TensorFlow algorithm by identifying clusters within 409 MSAs to detect those with high percentage of unsolved cases
- Potentially expose previously unknown serial killers by looking for MSAs and clusters with low clearance rates (see heat map below)



Build TensorFlow CNN

- Build supervised Convolutional Neural Network based on labeled police report data
- Current state-of-the-art model architecture for classification tasks

Conclusion

- This is a real-world problem in which applying appropriate data analytics tools can have societal implications
- Because it bears real-world implications, it is necessary to consult with domain knowledge experts
- Since serial murders are rare, comprising less than one percent of all murders committed in any given year, creating an algorithm to identify such cases will be an ongoing process[2]
- More analysis is necessary to discover a suitable algorithm for identifying serial killers

References
1. Thomas Hargrove. "Murder Accountability Project."
2. FBI. "Serial Murder."

http://www.stevens.edu/school-business/masters-programs/business-intelligence-analytics

Watson Book Recommender

Michael Pszonka

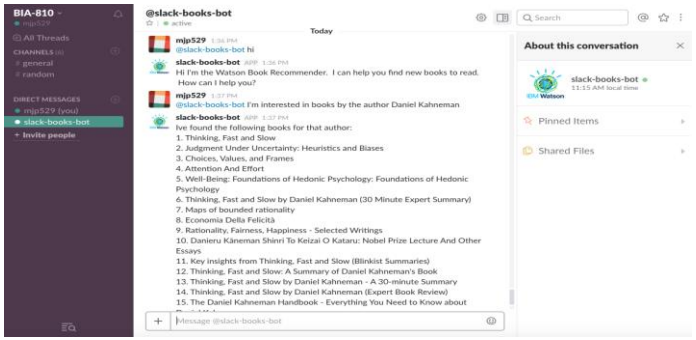
STEVENS INSTITUTE of TECHNOLOGY — Business Intelligence & Analytics

Introduction

- Over the past five years there has been tremendous growth in the usage of messaging applications, both as a tool for communicating with friends, as well as coordinating amongst teams in the workplace.
- Tied together with developments in artificial intelligence, companies have begun to create platforms that leverage this technology and encourage developers to build cognitive applications on top of them.
- The Watson Conversation service helps facilitate natural conversations between Watson and the user as they search for their next book.

Results

- The Watson Book Recommender is a cross-platform messaging "chatbot" that helps users narrow down their search for a new book. For example, is the user looking for individuals similar to their favorite author?
- Once trained on a corpus of queries and concepts related to books, Watson is capable of classifying user input and producing results similar to how a user would ask a friend for recommendations.
- This demo application utilizes the messaging app Slack, and can be shared on Slack's "Bot" Store alongside thousands of other bots that developers have built to perform tasks ranging from ordering a team lunch, to booking a flight.



Methods

Business Question
- Would it be possible to build a conversational agent that provided an alternative experience to rote Google searches for a new book?

Data & Scope
- Book data is obtained in real time from Goodreads, an Amazon company.
- This approach allows for a much larger corpus of data, while preventing the data from growing stale. (since new books are published daily)

Architecture
- Watson's Conversation API along with any messaging interface. (Facebook, Slack, etc.)

Conclusion

- Amazon has built Goodreads to be the social network for book worms and has become the go-to website for book recommendations.
- In addition to extending the recommender to answer more nuanced queries, it is conceivable that functionality could be built in to purchase books from Amazon through the Slack app.
- While Watson Book Recommender is linked to a Slack user interface, the cognitive component of the application is portable and can be exported to any interface such as Goodreads.com

http://www.stevens.edu/school-business/masters-programs/business-intelligence-analytics

Cognitive Hack-a-thon Winners

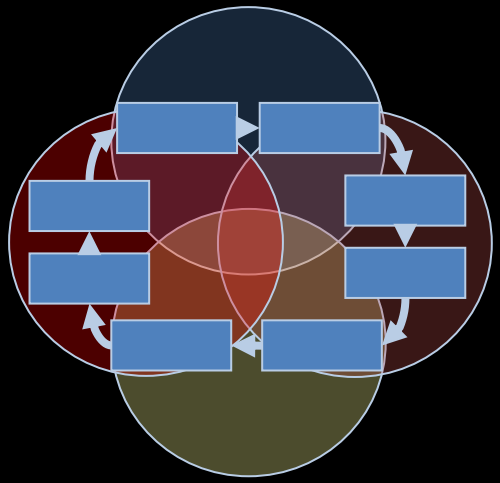
Problem Statement and Solution:

According to the National Institutes of Health (NIH), more than 80% of clinical trials in the United States fail to meet their patient recruitment timelines. Addressing this problem, we built a chatbot (MediBot) that initiates a conversation with potential candidates, analyzes their profile, and connects them with an appropriate trail.

Problem Statement and Solution:

Most of the search for medical literature is done through a website called PubMed. But, unfortunately, the existing system is very tedious to work with. So, addressing this problem, we added a layer of AI and developed an interactive search interface of the website which automates most of the process and makes search more optimized, fast and easy at the same time.

Cognitive Analytics and Evidence-Based Decision Making



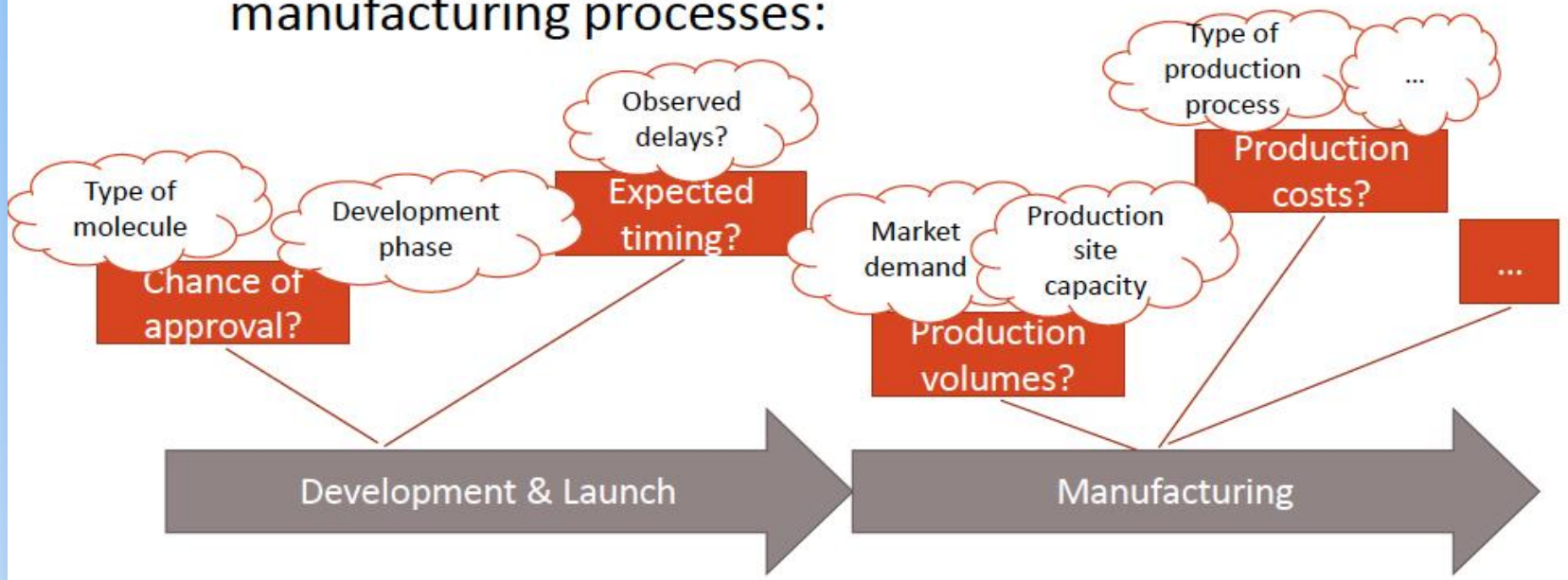
APPLICATION IN THE LIFE SCIENCES

Dr. Chris Asakiewicz

Scenario Analysis

Pharmaceutical New Product Development
Risk and Uncertainty Questions

- First step: identification of key risks/uncertainties and their drivers along the development and manufacturing processes:



Scenario Analysis

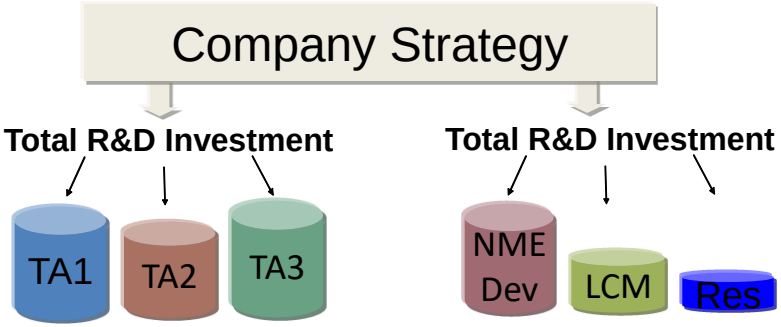
Role in Pharmaceutical R&D Portfolio Management

Company Strategy
R&D investment allocation

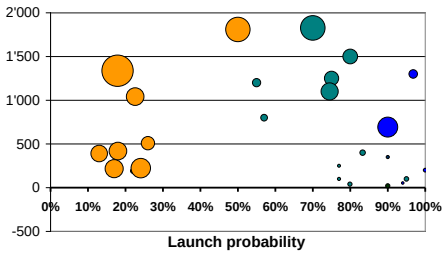
Portfolio Management

- Align portfolio with Strategy
- Maintain portfolio balance
- Maximize portfolio value

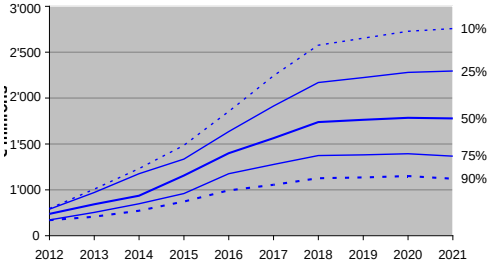
Resource Management



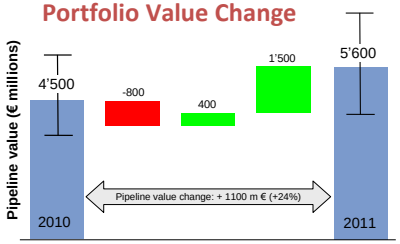
Value and Risk



Pipeline-derived sales



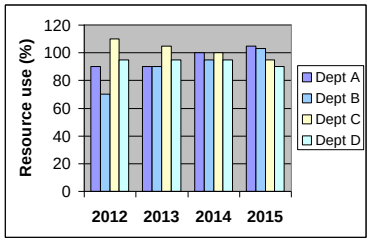
Portfolio Value Change



Project Prioritization & Optimization

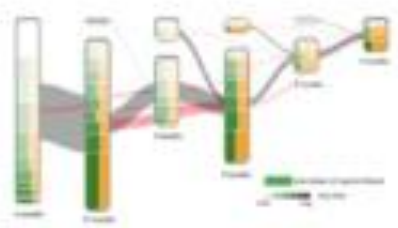
Project	Strategic	Commercial	Operational	Costs	Project score	Rank
A	90	70	50	60	68	1
B	65	65	50	75	64	2
C	85	85	30	50	63	3
D	75	80	30	65	63	4
E	55	45	55	90	61	5

Resource supply and demand, by project and Department



Computational Health

Disease Progression Modeling



Contextual & Behavioral Modeling

Translational Informatics

Visual Analytics and Cognitive Decision Support

Cognitive Informatics

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Special Communication

Cognitive informatics in biomedicine and healthcare

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ABSTRACT

Cognitive Informatics (CI) is a burgeoning interdisciplinary domain comprising of the cognitive and information sciences that focuses on human information processing, mechanisms and processes within the context of computing and computer applications. Based on a review of articles published in the *Journal of Biomedical Informatics* (JBI) between January 2001 and March 2014, we identified 57 articles that focused on topics related to cognitive informatics. We found that while the acceptance of CI into the mainstream informatics research literature is relatively recent, its impact has been significant – from characterizing the limits of clinician problem-solving and reasoning behavior, to describing coordination and communication patterns of distributed clinical teams, to developing sustainable and cognitively-plausible interventions for supporting clinician activities. Additionally, we found that most research contributions fell under the topics of decision-making, usability and distributed team activities with a focus on studying behavioral and cognitive aspects of clinical personnel, as they performed their activities or interacted with health information systems. We summarize our findings within the context of the current areas of CI research, future research directions and current and future challenges for CI researchers.

1. Introduction: Role of cognition in biomedical informatics

We are at a turbulent, yet exciting, phase in healthcare – *turbulent*, as the transformations in healthcare practice have been driven by paradigmatic shift toward the use of health information technology (HIT), both as a result of necessity and federal mandates; *exciting*, as such transformations have highlighted the central role of cognitive and behavioral sciences in developing usable systems that can provide high quality patient care. While there is a bright future, in terms of opportunities for researchers and practitioners who seek to engage in cognitive science research, it is also important to *reflect on past research* – to understand (a) the historical context and foundations of the development of cognitive research in biomedical informatics, (b) the theories, constructs and frameworks that drive the current research, and (c) the potential directions for future research. Within this focus, this special communication provides a broader context of the cognitive and behavioral research on HIT in biomedical informatics. In addition, we have also created a *virtual issue* of the *Journal of Biomedical Informatics* (JBI) that will provide a snapshot of the research that has been published in JBI pertaining to cognitive and social science research (see Refs. [1–57]).

Cognitive science is an interdisciplinary field that draws from psychology, computer science, linguistics, philosophy and anthropology to understand human activities including reasoning, decision-making and problem solving. Principles from cognitive science have been applied for studying the usability of medical devices and interfaces [55]; developing training, educational interventions and guidelines [39]; streamlining and improving workflow and clinical processes [29]; and for understanding the process of clinical judgment, reasoning and decision-making [58]. In summary, cognitive science provides a viable mechanism to inform our understanding in technology-rich clinical environments, and represents an important component of biomedical informatics [59]. Additionally, cognitive research has been a key to shaping and structuring the use of HIT, adapting to the various needs of the clinical environment.

Cognitive informatics (CI), by extension, is an interdisciplinary field comprising of cognitive and information sciences, specifically focusing on human information processing, mechanisms and processes within the context of computing and computer applications [60,61]. The focus of CI is on understanding work processes and activities within the context of human cognition and the design of interventional solutions (often engineering, computing and

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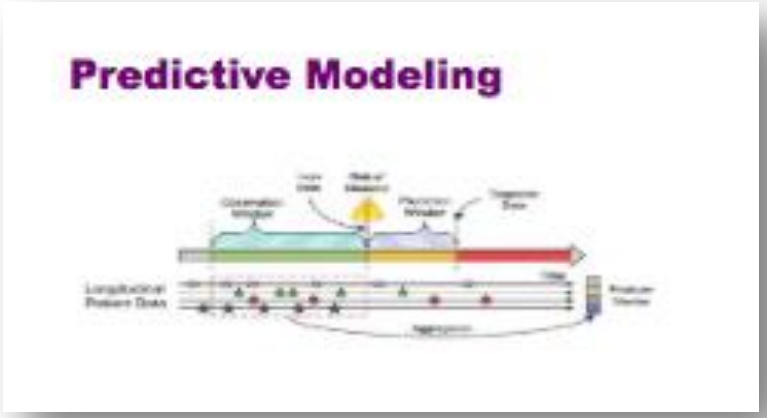
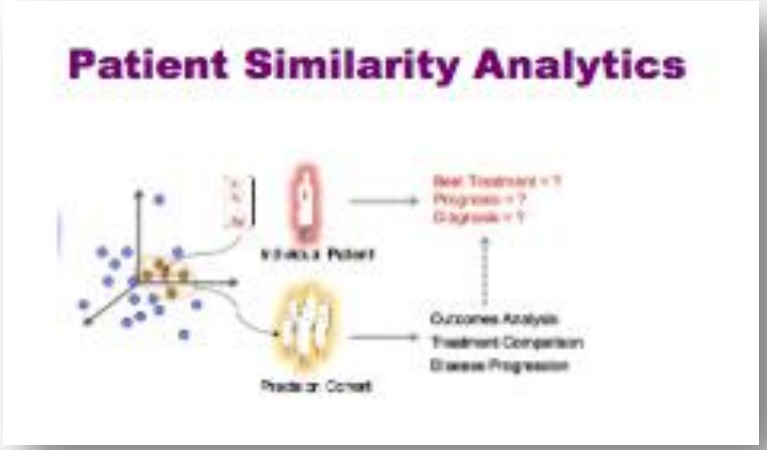




Smart Healthcare

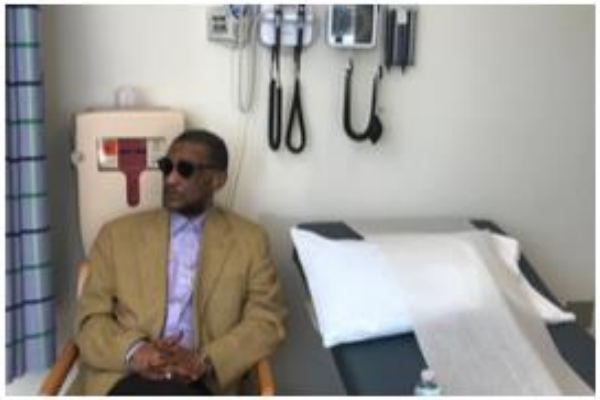
THE WALL STREET JOURNAL.

https://www.wsj.com/articles/how-ai-is-transforming-drug-creation-1498442760

LIFE | HEALTH | JOURNAL REPORTS: HEALTH CARE

How AI Is Transforming Drug Creation

Pharmaceutical companies hope computers can help them find new medications that are faster, cheaper—and more likely to be effective



Randell Sanders, a cancer patient, is contributing lab samples to a study of AI and drugs.
PHOTO: DANIELA HERNANDEZ/THE WALL STREET JOURNAL

The big difference between AI-driven drug trials and traditional ones, says Niven Narain, chief executive of Berg, is “we’re not making any hypotheses up front. We’re not allowing [human] hypotheses to generate data. We’re using the patient-derived data to generate hypotheses.”

Smart Healthcare

THE WALL STREET JOURNAL.

https://www.wsj.com/articles/how-apps-can-help-manage-chronic-diseases-1498443120

LIFE | HEALTH | JOURNAL REPORTS: HEALTH CARE

How Apps Can Help Manage Chronic Diseases

Hospitals and doctors have identified digital tools that can assist patients in dealing with ailments such as diabetes, heart disease and lung disease. The early results are promising.

Digital medicine—including remote monitoring and behavior modification—can improve outcomes in such costly and tough-to-manage categories as diabetes, heart disease and lung disease.
ILLUSTRATION: ANASTASIA VASILAKIS FOR THE WALL STREET JOURNAL

The Centers for Medicare and Medicaid Services currently covers some telehealth services, such as seeing a doctor over a video connection, and is now contemplating changes that might cover the use of digital services such as apps as well. The explosion in digital medicine has spurred researchers to develop apps for studies of diabetes, asthma and heart disease, and myriad technology startups are pitching disease-management apps to health-care providers.

Smart Healthcare

THE WALL STREET JOURNAL.

https://www.wsj.com/articles/smartphones-open-a-new-world-for-medical-researchers-1498442821

LIFE | HEALTH | JOURNAL REPORTS: HEALTH CARE

Smartphones Open a New World for Medical Researchers

Doctors say abundant health data gathered by phones produces better, more timely studies

Most medical studies depend on participants to self-report. But smartphones can track activity and other health-related data passively and dispassionately. ILLUSTRATION: OTTO STEININGER FOR THE WALL STREET JOURNAL

Researchers have long worried that clinical studies in general are skewed because most are limited to areas around research hospitals, so the study group isn't a representative cross-section of the population. An even greater concern is that, except for the controlled conditions of laboratory research studies, most people have been at best lax about reporting health issues or downright dishonest about, say, how much exercise they get.

Computer Science with Soul

http://dme.engin.umich.edu/grace/

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