Optimize Engineering with AI

IBM Requirements Quality Assistant (RQA)

Bosch Conversations

Stuttgart-Feuerbach, 29.05.2019

Dominik Jergus
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IBM Engineering
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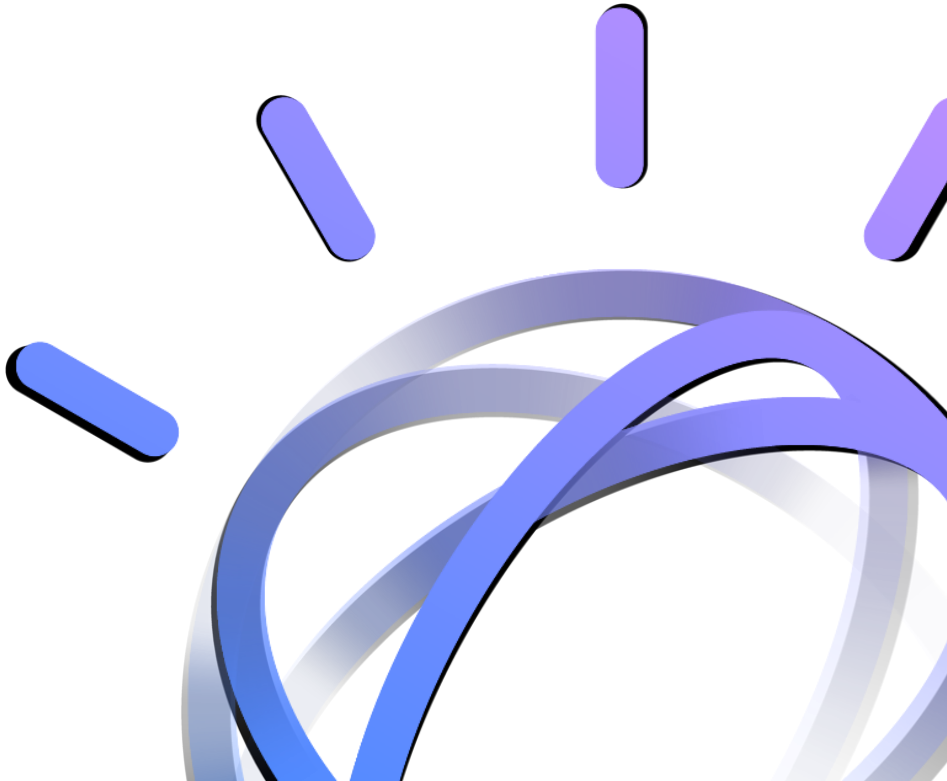

Agenda

- Watson, IBM‘s AI System for Business (B2B)
- Artifical Intelligence (AI) / Künstliche Intelligenz (KI)
- Cognitive Computing and Augmented Intelligence
- Machine Learning
- Requirements Management with AI
- Requirements Quality Assistant (RQA)
- Demo
- Q&A

DOORS / NG (RM)

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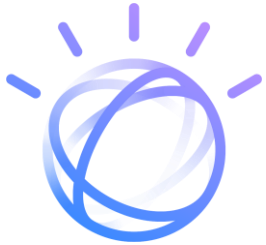


WATSON (KI/AI)

=

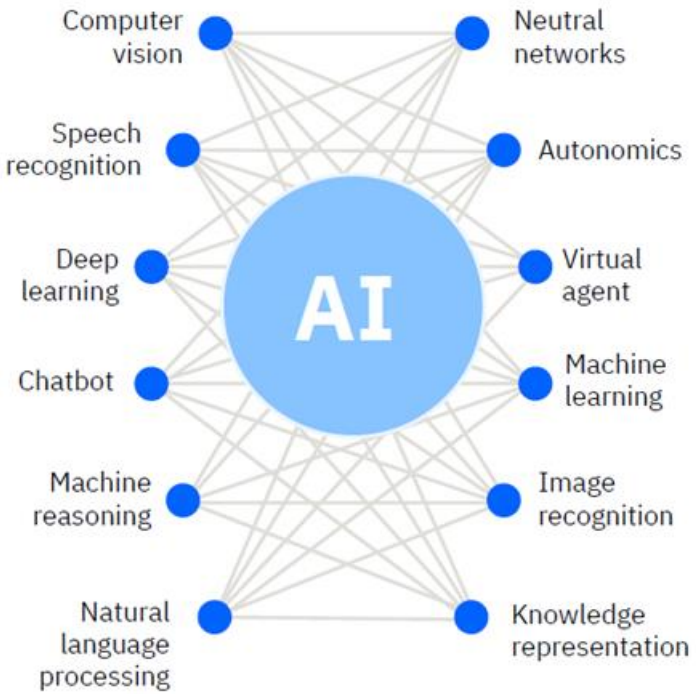
RQA (SaaS)

- **Reduce Costs**
- **Reduce Errors**
- **Train Employees**
- **Improve Productivity**
- **Strengthen Requirements**
- **Improve Customer Satisfaction**

IBM Watson

IBM Watson winning against two human grandmasters at Jeopardy! in 2011

The building blocks of AI



Watson, IBM‘s AI System for Business (B2B)

- Watson was created as a question answering (QA) computing system that IBM built to apply advanced **natural language processing**, **information retrieval**, **knowledge representation**, **automated reasoning**, and **machine learning** technologies to the field of open domain question answering.
- Watson was named after **IBM's first CEO**, industrialist **Thomas J. Watson**
- The computer system was **initially developed to answer questions on the quiz show Jeopardy!** and, **in 2011**, the Watson computer system competed on Jeopardy! against legendary champions **Brad Rutter and Ken Jennings**, winning the first place prize of $1 million for a charity project.
- **Watson is IBM‘s AI System for Business** (**B2B**) - Alexa, Siri, Cortana, etc. are rather seen as consumer based (**B2C**)
- The key **difference between QA technology and document search** is that document search takes a **keyword query** and returns a list of documents, ranked in order of relevance to the query (often based on popularity and page ranking), while QA technology takes a question expressed in natural language, **seeks to understand it in much greater detail, and returns a precise answer to the question**.
- When created, IBM stated that, "**more than 100 different techniques are used to analyse natural language**, identify sources, find and **generate hypotheses**, find and **score evidence**, and merge and rank hypotheses."
- In recent years, the Watson capabilities have been extended and the way in which Watson works has been changed to take advantage of new deployment models (Watson on IBM Cloud) and evolved machine learning capabilities and optimised hardware available to developers and researchers. It is no longer purely a question answering computing system designed from Q&A pairs but can now '**see**', '**hear**', '**read**', '**talk**', '**taste**', '**interpret**', '**learn**' and '**recommend**'.

Artificial Intelligence (AI) / Künstliche Intelligenz (KI)

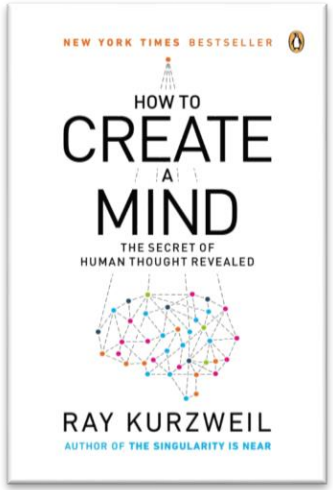
HAL letters shifted by 1 Bit -> IBM ;)

- The term "artificial intelligence" is used to describe **machines that mimic "cognitive" functions** that humans associate with other human minds, such as **"learning" & "problem solving"**.
- The truth is that **AI is hard to define**, because intelligence is hard to define in the first place.
- Our **definition of AI changes**. In fact, John McCarthy, who coined the term “Artificial Intelligence” in 1956, stressed that “as soon as it works, no one calls it AI anymore.”
- Today, many of the **rules- and logic-based systems** that were previously considered Artificial Intelligence are no longer classified as AI. In contrast, **systems that analyse and find patterns in data (machine learning) are becoming the dominant form of AI**.
- Three main categories of AI:
  1. **Artificial Narrow/Weak Intelligence (ANI)**
     is the only form of Artificial Intelligence that humanity has achieved so far! This is AI that is good at **performing a single task**, such as playing chess or Go, making purchase suggestions, sales predictions and weather forecasts, or even driving a car autonomously.

  2. **Artificial General/Strong Intelligence (AGI)**
     also known as **human-level AI**, is the type of Artificial Intelligence that can understand and reason its environment as a human would. **We’ve been saying for decades that it’s just around the corner**.

  3. **Artificial Super Intelligence (ASI)**
     when AI becomes **much smarter than the best human brains** in practically every field, including scientific creativity, general wisdom and social skills. **ASI is even more vague than AGI** at this point.

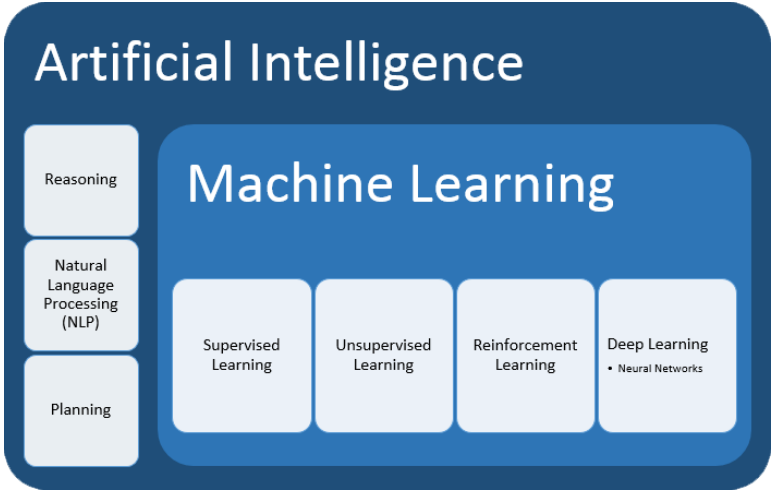
Cognitive Computing and Augmented Intelligence

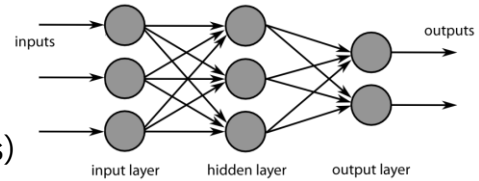


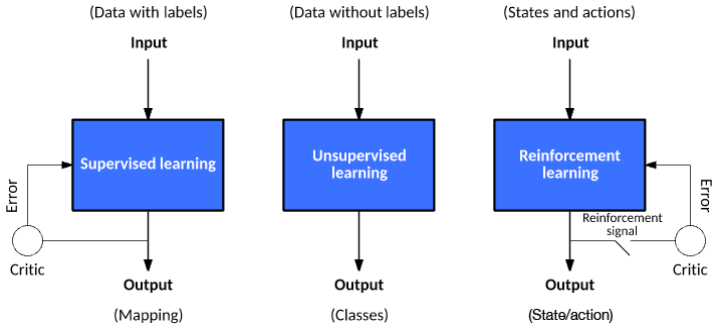
- Artificial intelligence (AI) has garnered a **negative reputation** as a force that will eventually destroy humanity.
- IBM prefers to speak rather about **Cognitive Computing or Augmented Intelligence** instead of Artificial Intelligence.
- The word *cognition* comes from the Latin verb *cognosco* (*con*, '**with**', and *gnōscō*, '**know**'), meaning '**I know, perceive**'), meaning 'to conceptualize' or 'to recognize'.
- **Augmented (vermehrte, vergrößerte) Intelligence** should stress the combination of **Man AND Machine**!
- When you hear Cognitive, think **pattern recognition (Mustererkennung)**!
- The book „**How to create a mind**" from **Ray Kurzweil** describes that the **thinking parts of our brains** are made out of building blocks -> **Neurons and Neural Networks**
- The breakthrough in Cognitive Computing has been **the advent of Machine Learning capabilities** with the **vast amount of data (IoT, Mobile) to learn from** and the **massive CPU power & storage capacities of the Cloud**.
- The goal of Cognitive Computing is to **amplify human cognition** and allow people to **make better decisions**.
- Watson is particularly good, when dealing with **large amounts** of **structured (~20%)** & **unstructured data (~80%)**
- Today **Watson is a building set (Baukasten) of various KI algorithms** for customers and projects to be used

Machine Learning (ML)

- Machine learning (ML) is the **scientific study of algorithms and statistical models** that computer systems use to effectively perform a specific task without using explicit instructions, **relying on patterns and inference** instead.
- It is seen as a **subset of artificial intelligence**. Machine learning algorithms build a **mathematical model of sample data**, known as "training data", in order to make predictions or decisions **without being explicitly programmed** to perform the task.
- Machine learning algorithms are used in a wide variety of applications, such as **email filtering, detection of network intruders, and computer vision**, where it is infeasible to develop an algorithm of specific instructions for performing the task.
- **Arthur Lee Samuels**, an IBM researcher, developed one of the earliest machine learning programs – a self-learning program for playing checkers. In fact, he **coined the term *machine learning***.
- Types of Learning algorithms
  - Supervised Learning
  - Unsupervised Learning
  - Reinforcement Learning
  - Deep Learning (Neural Networks)







The complexity in product development is driving an explosion of engineering artifacts – it's hard to keep up!

Automotive

150M Lines of code in new Ford F-150 Truck from 155K in 2003

40% of total IT Budget spent on QA and testing by 2019

Electronics

12M lines of code in mobile phone

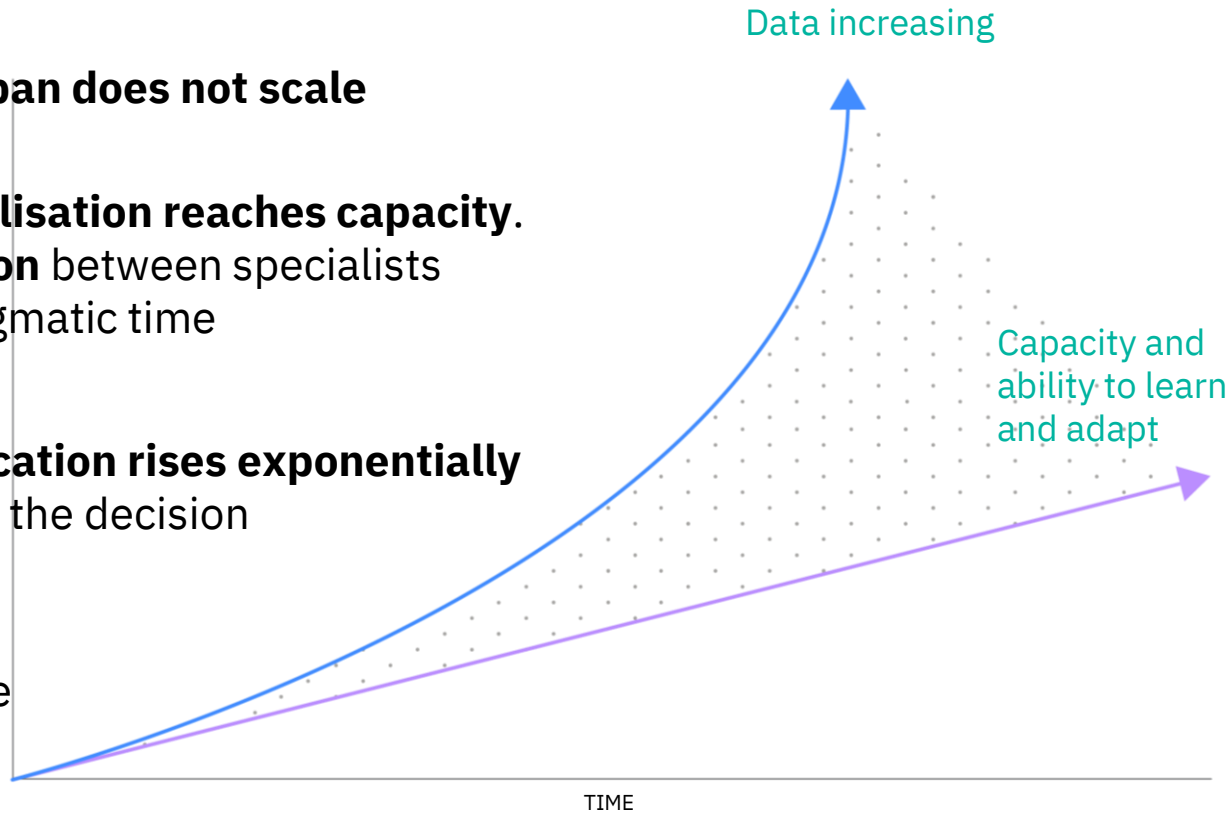
1.4M lines of code in robotic surgical system

Aerospace & Defense

90% of F-35 fighter jet functionality is software driven

Engineering knowledge has become big data

- **Human brain and life-span does not scale**
- Usual **strategy of specialisation reaches capacity**. **Too much communication** between specialists to solve problems in pragmatic time
- **Weight of the communication rises exponentially** with every new person in the decision making process
- Specialization also create "**responsibility gaps**"

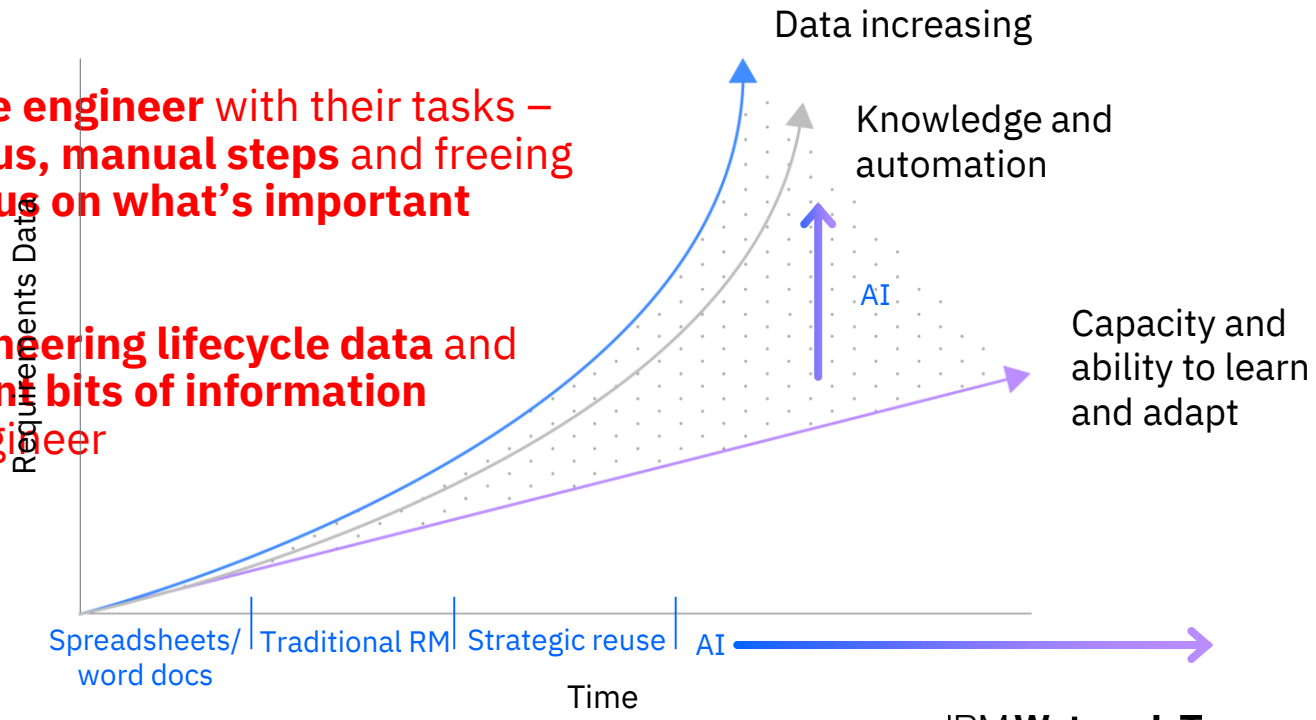


The evolution of requirements management *leads to knowledge driven requirements*

- AI will help **bridge** that **gap** in **two levers**

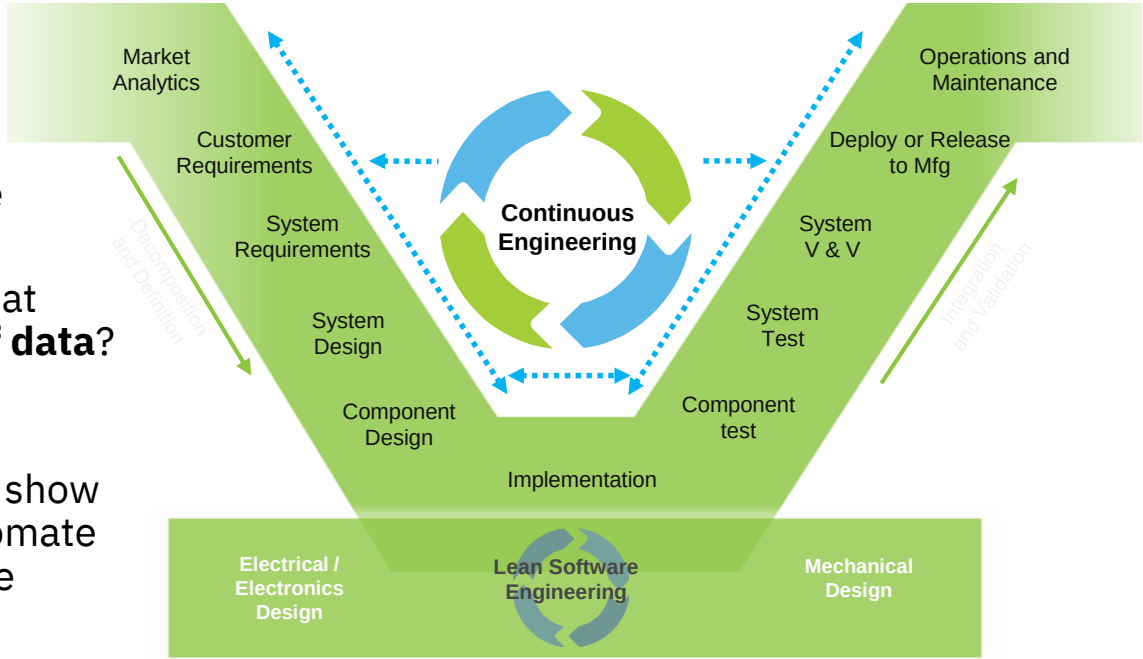
- **Lever 1 - assisting the engineer** with their tasks – **automating** the **tedious, manual steps** and freeing up the engineer to **focus on what's important**

- **Lever 2 - mining engineering lifecycle data** and extracting only **relevant bits of information and trends** for the engineer



IBM's approach how to help engineers to work smarter: Inject automation and intelligence across the engineering lifecycle

- Use those two levers **across the lifecycle**
- Where in the lifecycle do engineers do **manual, low-value tasks that can be automated**?
- Are there areas in the lifecycle that are experiencing an **explosion of data**? How do we **mine** that **data** and only surface the **relevant bits**?
- **Two successful AI case studies** show where AI helped companies automate some of their processes and mine insights from data …



AUTOGLASS®

Solution:

Autoglass built the world's first automated vehicle body damage assessment and quote generation system. Using the IBM Watson Visual Recognition service, the system analyzes the photos that customers upload when they submit a body damage claim, applying the same classification logic as Belron's highly experienced damage assessment advisors.

"We're able to automate nearly half of our body damage claims assessments using image recognition technology, and we expect that rate to get even higher."

—Dafydd Hughes, IT Manager at Autoglass BodyRepair

IBM Watson Visual Recognition

- Shortens the claims cycle for certain damage assessments **by more than 95%**
- **Enriches client experience** through personalized conversation flows and real-time answers
- Enables damage assessment advisors to **focus on more complex damage claims**

woodside

We teach Watson to think like an engineer.

Watson teaches us to think like a thousand engineers.

Solution:
Working with Watson, Woodside Energy built a customized tool that allows its employees to find detailed answers to highly specific questions - even on remote oil and gas facilities.

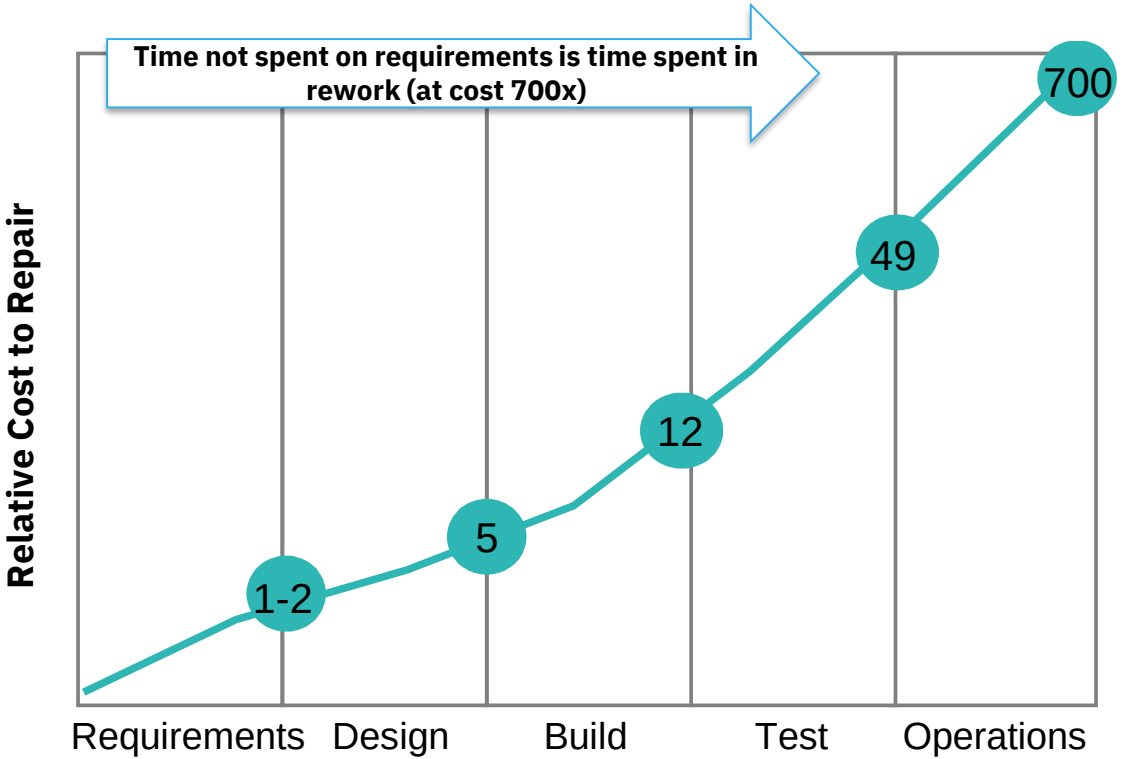
"It's helped our engineers get up to speed very quickly on what has already been done and how the projects were managed in the past. We can learn from the past and there's no need to reinvent the wheel."

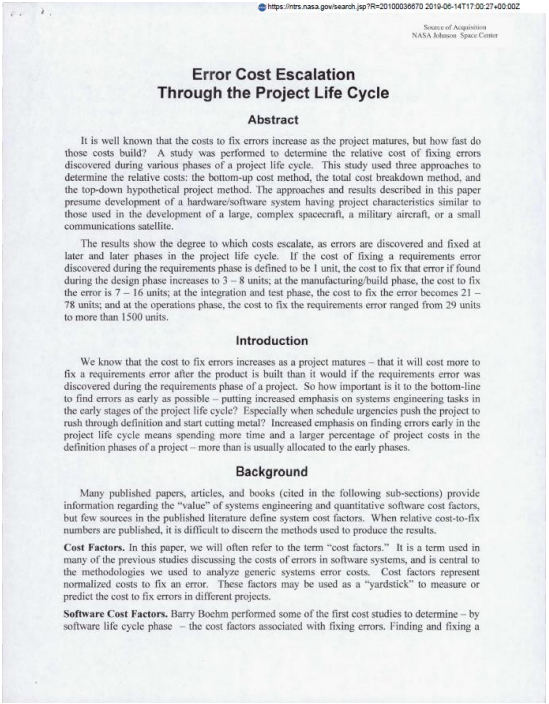
— Caitlin Bushell, Graduate Process Engineer at Woodside

- IBM Watson Knowledge Studio
- IBM Watson Discovery
- IBM Watson Assistant
- IBM Watson Explorer
- IBM Cloud

- **38,000 Woodside documents** were used to train the solution — this would take a human over five years to read
- **30 years of practical engineer experience** at the fingertips of all Woodside employees
- **75% decrease** in time employees spend searching for expert knowledge

The cost to fix software defects rises exponentially with each successive phase of the project life cycle





https://ntrs.nasa.gov/search.jsp?R=20100036670 2019-06-14T17:00:27+00:00Z

Source of Acquisition
NASA Johnson Space Center

Error Cost Escalation Through the Project Life Cycle

Abstract

It is well known that the costs to fix errors increase as the project matures, but how fast do those costs build? A study was performed to determine the relative cost of fixing errors discovered during various phases of a project life cycle. This study used three approaches to determine the relative costs: the bottom-up cost method, the total cost breakdown method, and the top-down hypothetical project method. The approaches and results described in this paper presume development of a hardware/software system having project characteristics similar to those used in the development of a large, complex spacecraft, a military aircraft, or a small communications satellite.

The results show the degree to which costs escalate, as errors are discovered and fixed at later and later phases in the project life cycle. If the cost of fixing a requirements error discovered during the requirements phase is defined to be 1 unit, the cost to fix that error if found during the design phase increases to 3 – 8 units; at the manufacturing/build phase, the cost to fix the error is 7 – 16 units; at the integration and test phase, the cost to fix the error becomes 21 – 78 units; and at the operations phase, the cost to fix the requirements error ranged from 29 units to more than 1500 units.

Introduction

We know that the cost to fix errors increases as a project matures – that it will cost more to fix a requirements error after the product is built than it would if the requirements error was discovered during the requirements phase of a project. So how important is it to the bottom-line to find errors as early as possible – putting increased emphasis on systems engineering tasks in the early stages of the project life cycle? Especially when schedule urgencies push the project to rush through definition and start cutting metal? Increased emphasis on finding errors early in the project life cycle means spending more time and a larger percentage of project costs in the definition phases of a project – more than is usually allocated to the early phases.

Background

Many published papers, articles, and books (cited in the following sub-sections) provide information regarding the "value" of systems engineering and quantitative software cost factors, but few sources in the published literature define system cost factors. When relative cost-to-fix numbers are published, it is difficult to discern the methods used to produce the results.

Cost Factors. In this paper, we will often refer to the term "cost factors." It is a term used in many of the previous studies discussing the costs of errors in software systems, and is central to the methodologies we used to analyze generic systems error costs. Cost factors represent normalized costs to fix an error. These factors may be used as a "yardstick" to measure or predict the cost to fix errors in different projects.

Software Cost Factors. Barry Boehm performed some of the first cost studies to determine – by software life cycle phase – the cost factors associated with fixing errors. Finding and fixing a

[(2004) NASA Publication]

Current solutions … and why they can miss errors

Rules engines

– Simple key word searches cannot understand words in context

- Example of “clear”
- Ambiguous: “The GPS system shall provide a **clear perspective** of the road”
- Not ambiguous: “The GPS System shall **clear the display** on transition to power off mode”

Peer review

– Difficult to enforce across teams

– Manual, tedious review of long documents

Checklists

– Limited capacity to keep track of all quality indicators (cognitive span is 7 +/- 2 things)

High quality requirements are critical for a project's success

Test Your Requirements Management Skills: http://ibm.biz/rqa_quiz

Completeness
Unfinished requirements lead to preventable confusion and delays

Consistency
The more consistent requirements are the fewer opportunities there are for errors

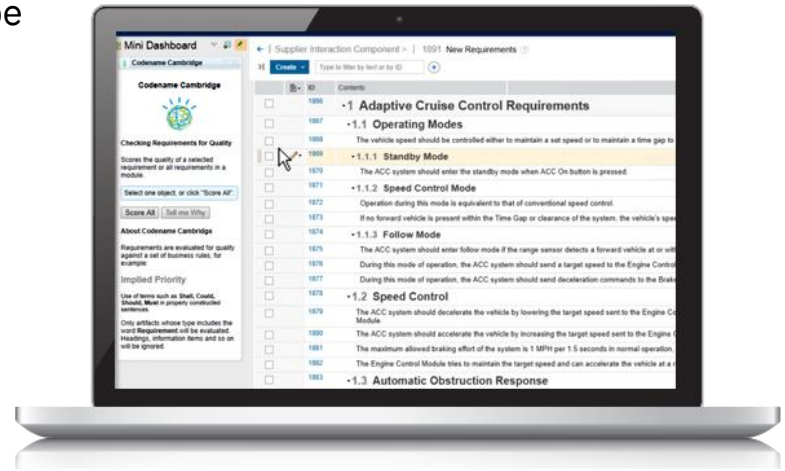
Accuracy
Accurate requirements reliably articulate the objectives of stakeholders

IBM Requirements Quality Assistant (RQA)

https://www.ibm.com/us-en/marketplace/requirements-quality-assistant

New Watson capability embedded inside **DOORS NG** and **DOORS** …

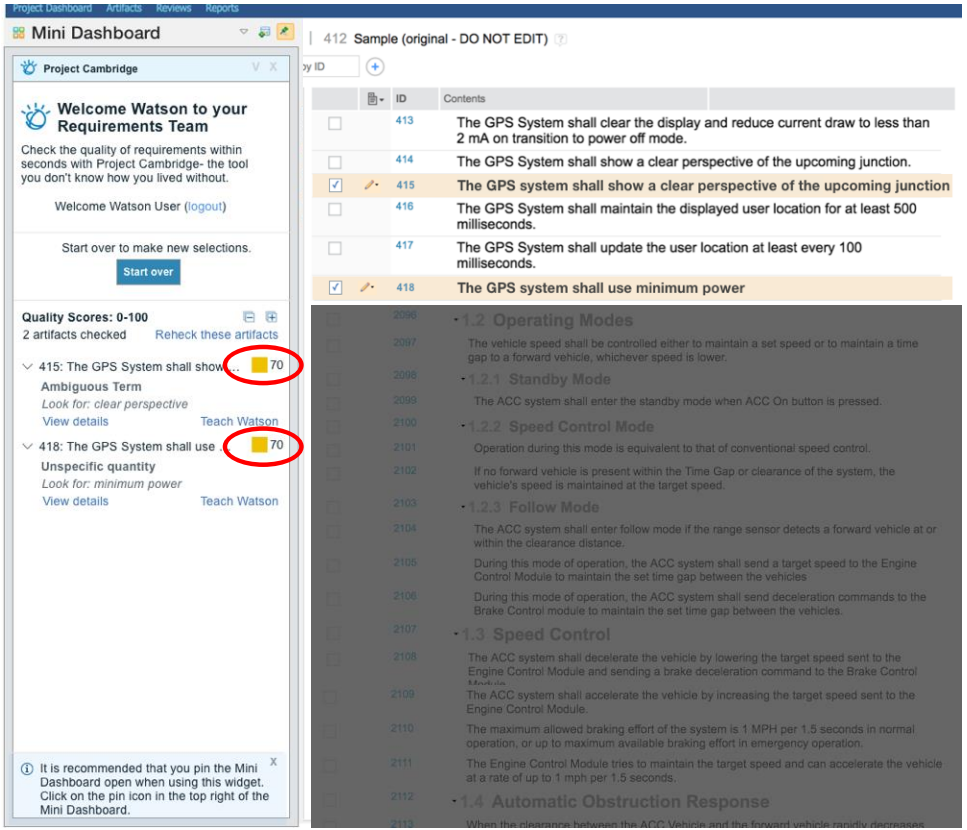
- **Removes risk and ambiguity** in the requirements authoring phase **out-of-the-box** by using **AI** (Watson Natural Language Understanding)
- **Pre-trained** to detect **key quality indicators** designed to be consistent with the **INCOSE Guidelines** for Writing Good Requirements
- Authors **receive coaching** from Watson to **improve the quality of the requirement** as it is being written



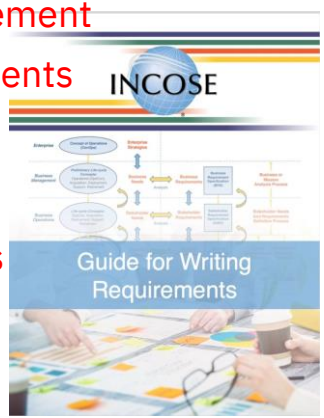
Enterprise benefits (**400 engineers example**)

- Reduce the cost of defects by **60%** to save **$3.9M**
- Reduce cost of manual reviews by **25%**
- Retain engineering **expertise for junior engineers**

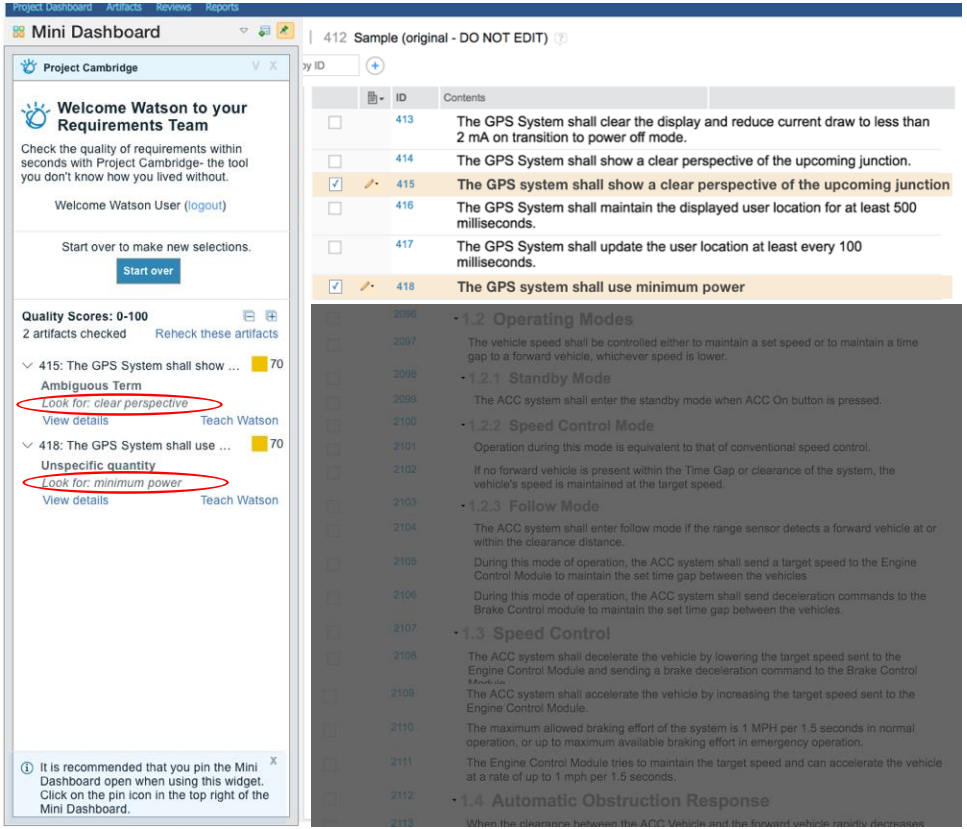
Grading and quality issues



- **Grades requirements** against a criteria that was designed to be consistent with the **INCOSE Guidelines** for Writing Good Requirements
- **Pre-trained** to detect 10 quality **issues**
  1. Unclear actor or user
  2. Compound requirement
  3. Negative requirements
  4. Escape clause
  5. Missing units
  6. Missing tolerances
  7. Ambiguity
  8. Passive
  9. Incomplete requirements
  10. Unspecific quantities

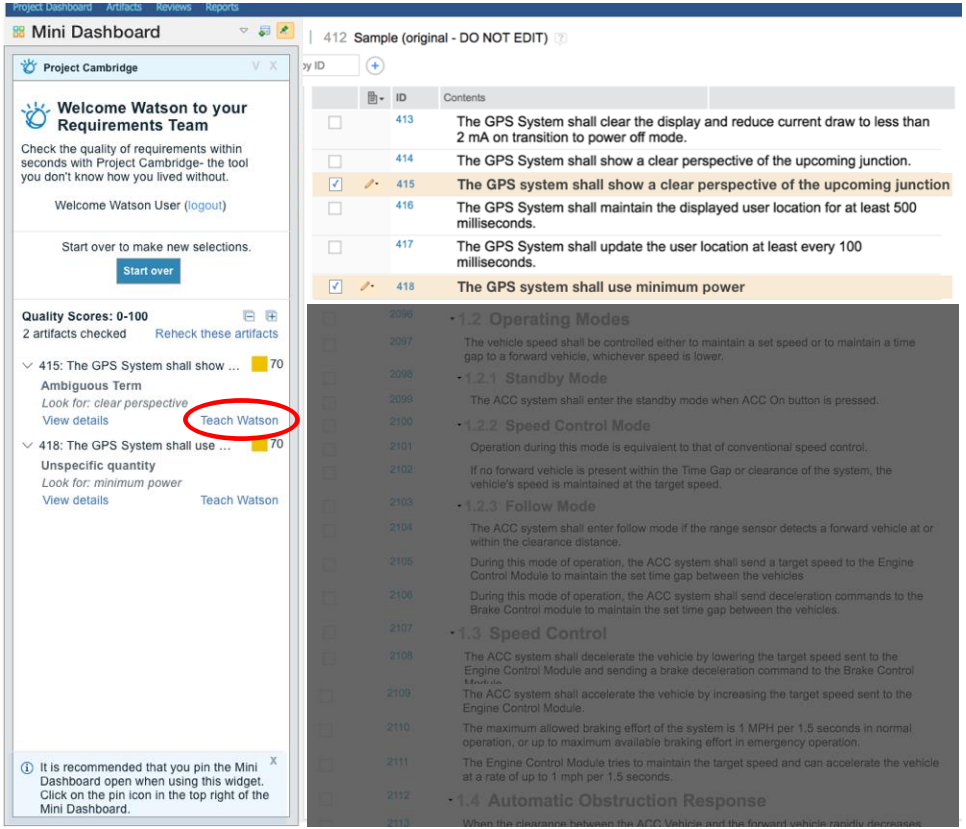


Identification and reasoning



- **Identifies** exactly **what's wrong** with the requirement
- **Displays the issue** to the requirements engineer

Learning and improving



- **RQA learns** from the requirements engineer
- Becomes **"smarter" over time**

- But also the requirements engineer **learns from RQA** and **becomes better in writing good requirements** over time!

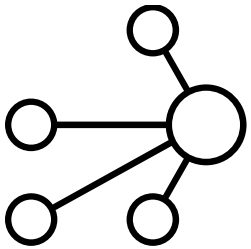
Our approach

Watson Services

Customer Solution

Our approach: *Pre-train Watson for you*

Watson Services



Watson Natural Language Understanding

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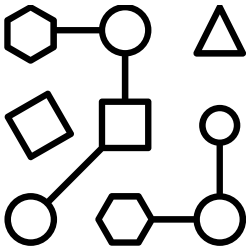

Architecture and pre-built NLP model

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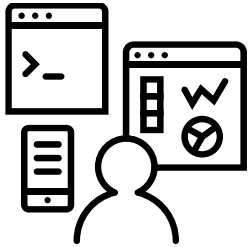
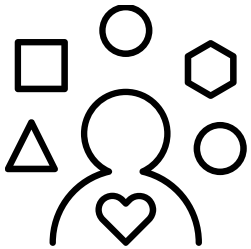


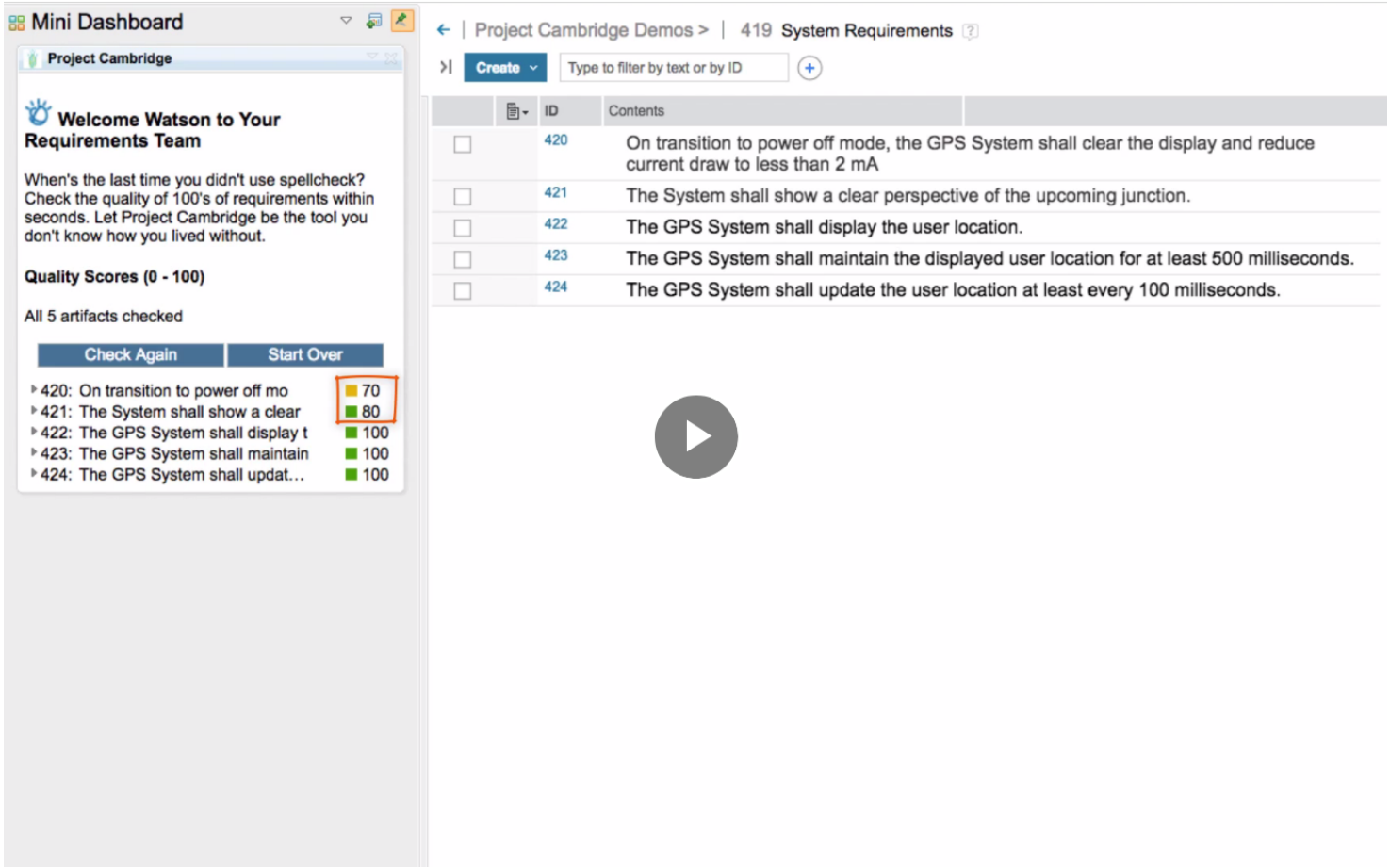
Requirements Public Domain Data

Customer Solution



IBM Requirements Quality Assistant

DEMONSTRATION



https://www.youtube.com/watch?v=RcKVxWjWFF8

ROADMAP

RQA Roadmap

Febr. 2019 — 2019+

First GA release for RQA

- Plug-in for DNG
- Teach Watson Feature
- Usage monitoring on the dashboard
- OpenSocial gadget URL installation
- User management
- Automatic provisioning

2019 Releases for RQA

- RQA reporting
- DOORS plug-in
- Storing the quality scores
- Customization of business rules and scores
- Trial landing page

Future plans for RQA

- Enable Tokens
- Full on prem version
- Industry-specific models
- Identify duplicates or inconsistent, conflicting requirements
- Foreign languages support

QUESTIONS? & ANSWERS!

FRAGEN? & ANTWORTEN!

Contact

Danke für Ihre Aufmerksamkeit!

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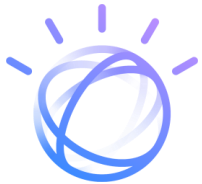
Code reader download (recom. Android: QR Droid, BeeTagg / iPhone: Qrafter, i-nigma)
Code scanning, contact store directly

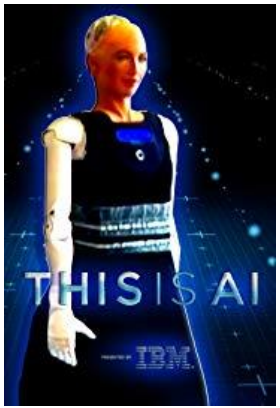
Thank you, for your attention!

Additional Resources 1/2:

- **IBM Requirements Quality Assistant (RQA)**
  - https://www.ibm.com/us-en/marketplace/requirements-quality-assistant
  - https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?infotype=an&subtype=ca&appname=gpateam&supplier=897&letternum=ENUS218-353
  - http://www-01.ibm.com/common/ssi/ShowDoc.wss?docURL=/common/ssi/rep_sm/2/649/ENUS5900-A32/index.html&lang=en&request_locale=en
  - Video: https://www.youtube.com/watch?v=RcKVxWjWFF8
  - Documentation: https://www.ibm.com/support/knowledgecenter/SS3UPN/com.ibm.help.rm.assist.doc/helpindex_rm_assistant.html
  - Quiz (Test your requirements management skills): http://ibm.biz/rqa_quiz
- **IBM Watson**
  - https://www.ibm.com/watson/
  - https://www.ibm.com/watson/de-de/
  - https://www.youtube.com/watch?v=_Xcmh1LQB9I
  - https://www.youtube.com/watch?v=P18EdAKuC1U
  - https://www.industry-of-things.de/was-watson-kann-und-was-nicht-a-672872/
  - https://en.wikipedia.org/wiki/Watson_(computer)
  - https://de.wikipedia.org/wiki/Watson_(K%C3%BCnstliche_Intelligenz)
- **This is AI, presented by IBM - Discovery Channel Videos (Part 1-4) on YouTube:**
  - https://www.youtube.com/watch?v=H3P87qCdqk4
  - https://www.youtube.com/watch?v=Krqy-Eso3a8
  - https://www.youtube.com/watch?v=E0uehCrPMlU
  - https://www.youtube.com/watch?v=EJEvwwghTJw
- **Don't fear superintelligent AI - Grady Booch (IBM)**
  - https://www.youtube.com/watch?v=z0HsPBKfhoI
- **IBM Research AI - Advancing AI for industry and society**
  - https://www.research.ibm.com/artificial-intelligence/
- **IBM DOORS Next Generation**
  - https://jazz.net/products/rational-doors-next-generation/
- **IBM Continuous Engineering Webinars (free)**
  - https://www.gotostage.com/channel/ibm
- **IBM Continuous Engineering Product Previews (free)**
  - https://jazz.net/previews/
- **IBM Continuous Engineering**
  - https://jazz.net/products/continuous-engineering-solution/
  - https://www.ibm.com/internet-of-things/learn/continuous-engineering-IoT/
  - https://www.ibm.com/internet-of-things/solutions/systems-engineering
  - https://www.ibm.com/us-en/marketplace/engineering-solutions-on-cloud



Discovery CHANNEL



Additional Resources 2/2:

- **Cognitive Computing / Augmented Intelligence**
  - https://www.youtube.com/watch?v=j98rY3vhPhE
  - https://www.youtube.com/watch?v=wuvBMAyNqeQ
- **Studie bzgl. Einschätzung von Künstlicher Intelligenz in Deutschland**
  - https://yougov.de/news/2018/09/11/kunstliche-intelligenz-deutsche-sehen-eher-die-ris/
  - https://www.heise.de/newsticker/meldung/Kuenstliche-Intelligenz-Deutsche-sehen-mehrheitlich-Risiken-4160306.html
- **Zwischen Alarmismus und Utopie. Von der Zukunft der Arbeit im Zeitalter der Digitalisierung, BR2 Podcast**
  - https://www.br.de/mediathek/podcast/radioreportage/zwischen-alarmismus-und-utopie-von-der-zukunft-der-arbeit-im-zeitalter-der-digitalisierung-1/1388240
- **Leschs Kosmos - K.O. durch KI? und weitere Videos (ZDF, Prof. Harald Lesch)**
  - https://www.youtube.com/watch?v=IuVmd1USAFU
  - https://www.zdf.de/wissen/leschs-kosmos/ko-durch-ki-keine-angst-vor-schlauen-maschinen-100.html
  - https://www.zdf.de/wissen/leschs-kosmos/uebrigens-zu-kuenstlicher-intelligenz-102.html
  - https://www.zdf.de/wissen/leschs-kosmos/uebrigens-zur-digitalen-welt-102.html
  - https://www.zdf.de/wissen/leschs-kosmos/roboworld-102.html
- **Künstliche Intelligenz: Wie Deutschland seinen Wohlstand aufs Spiel setzt, report München, Doku**
  - https://www.youtube.com/watch?v=mIk5qGFLri8
- **Doku über künstliche Intelligenz - Frag deinen Kühlschrank, ARD-alpha, 21.01.2019, 20:15 Uhr, 44 Min.**
  - https://www.br.de/mediathek/video/doku-ueber-kuenstliche-intelligenz-frag-deinen-kuehlschrank-av:5c0824160383f0001c0fa1ec
- **Wie Künstliche Intelligenz deutsche Unternehmen prägt, 11.03.2019**
  - https://www.ibusiness.de/aktuell/db/292804SUR.html
- **KI Strategie der Bundesregierung**
  - https://www.bundesregierung.de/breg-de/themen/digital-made-in-de/ki-als-markenzeichen-fuer-deutschland-1549732
  - https://t3n.de/news/laut-ki-forscher-setzt-die-bundesregierung-auf-veraltete-konzepte-1149442/
  - https://www.boell.de/de/2019/01/28/kuenstliche-intelligenz-schlusslicht-oder-weltspitze-der-ki-standort-deutschland

IBM „For Dummies“ eBooks (free download):