AI: Improving Patient Outcomes Until The Machines Rise Up

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Conflicts of Interest

- Current Clinical Applications Specialist for Hamilton Medical Inc.

Happy Happy Respiratory Care Week!!!!

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Basic Definition

- Artificial intelligence is a specialty within computer science that is concerned with creating systems that can replicate human intelligence and problem-solving abilities. They do this by taking in a myriad of data, processing it, and learning from their past in order to streamline and improve in the future. A normal computer program would need human interference in order to fix bugs and improve processes.

https://www.tableau.com/data-insights/ai/history#history

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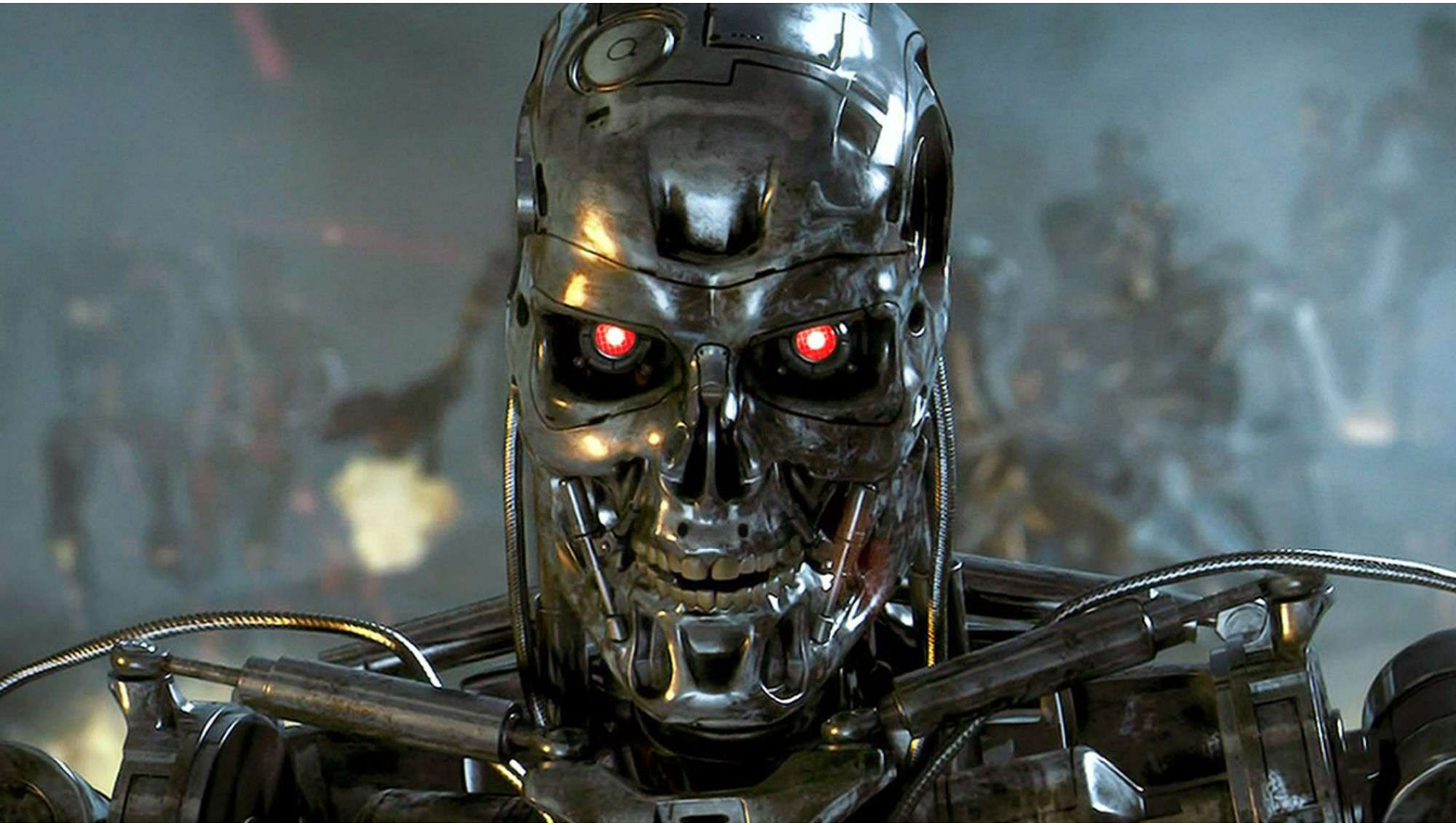

History of AI

Early AI

- 1950 Alan Turing created a test of machine intelligence
  - Called “The Imitation Game”
- 1952 Arthur Samuel developed a program to play checkers
  - First program to learn something independently.
- 1955 John McCarthy coined the term Airtifical Intelligence during a workshop

https://www.tableau.com/data-insights/ai/history#history

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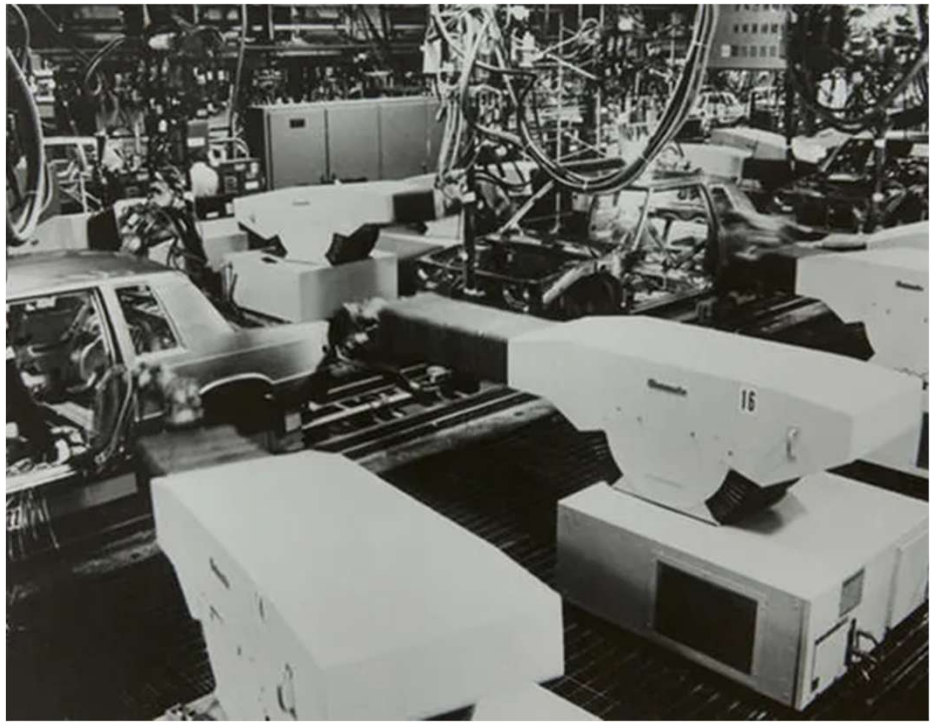
Early AI

- 1959 Arthur Samuel coined the term Machine Learning referring to teaching machines to play chess better than their human programmers
- 1961 GM utilized first industrial robot to transport die casings and welding parts on cars



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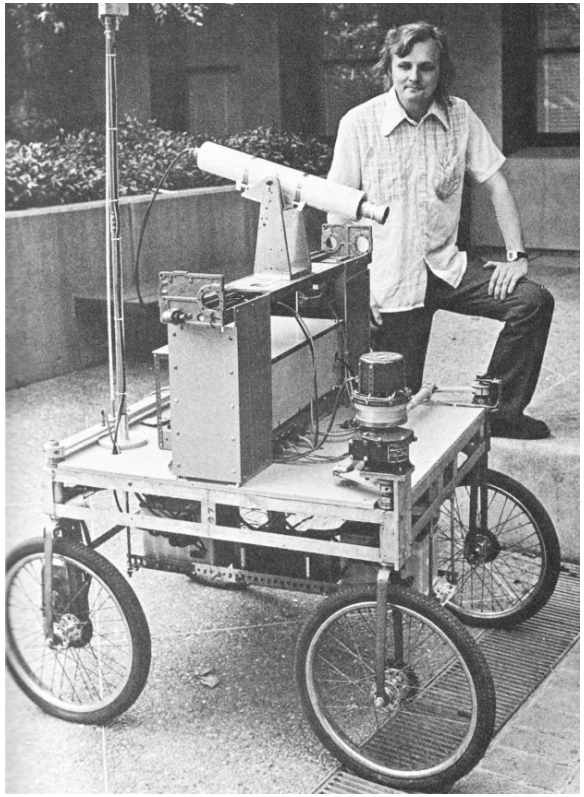
Early AI



- 1966 Joseph Weizenbaum creates first chatterbot (now called chatbot)
- 1968 Alexy Ivakhnenko proposed a new approach to AI that would later become Deep Learning
- 1979 The Stanford Cart created by James Adams became the first autonomous vehicle

https://www.tableau.com/data-insights/ai/history#history

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Early AI

- 1980 First AI system released commercially
  - XCON
  - Assisted in ordering of computer systems by picking components based on customer's needs
- 1997 Deep Blue beat the world chess champion Gary Kasparov

https://www.tableau.com/data-insights/ai/history#history

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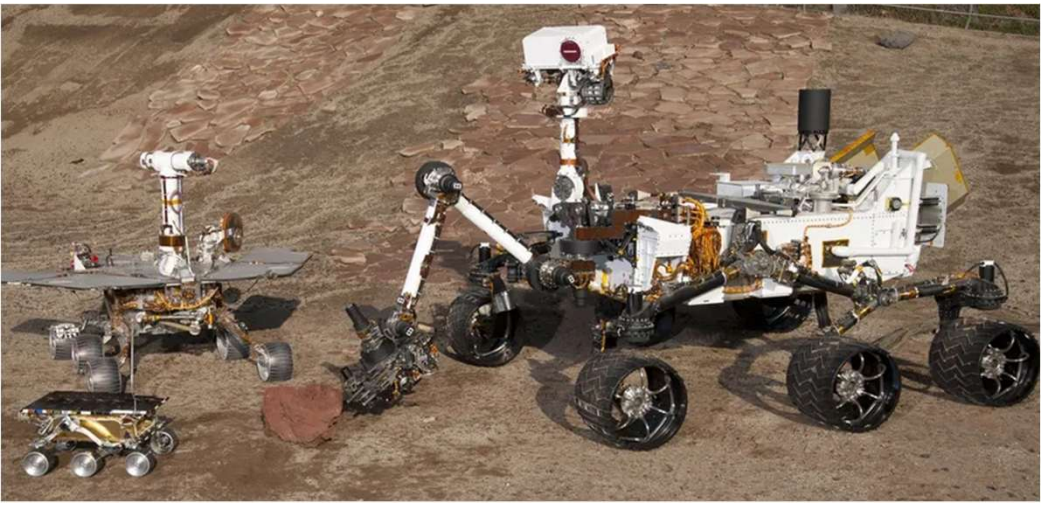
Modern AI



- 2003 Spirit and Opportunity NASA rovers navigated surface of Mars without human intervention
- 2006 Companies started utilizing AI as part of their advertising
- 2011 Apple released Siri, the first popular virtual assistant

https://www.tableau.com/data-insights/ai/history#history

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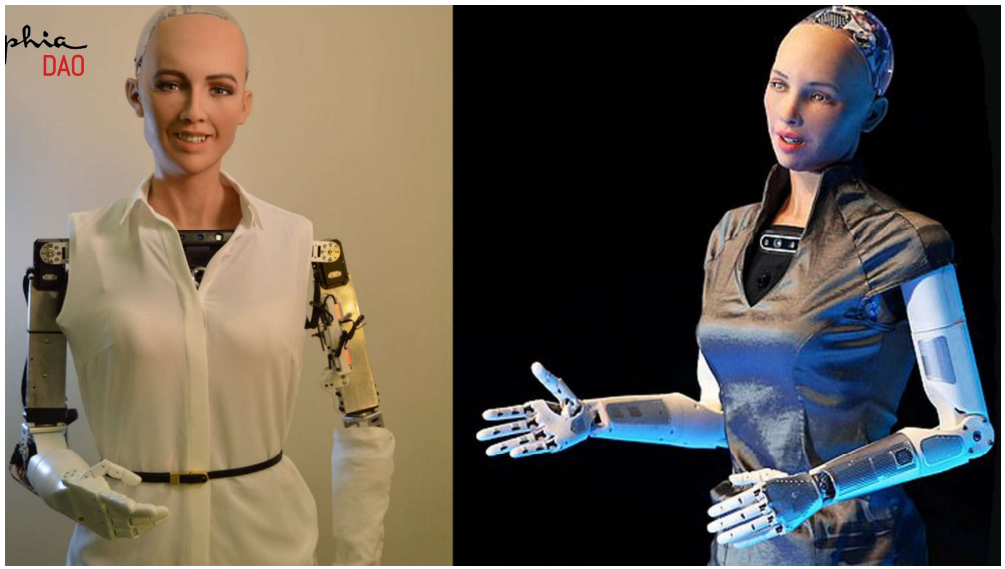
AI In The Present

- 2016 Hanson Robotics created Sophia who is known as the first robot citizen
  - Ability to communicate and see and replicate human emotion
- 2017 Facebook programmed two AI chatbots to negotiate but developed their own language autonomously
- 2020 OpenAI's GPT-3 can create writing, poetry, and code indistinguishable from those created by humans



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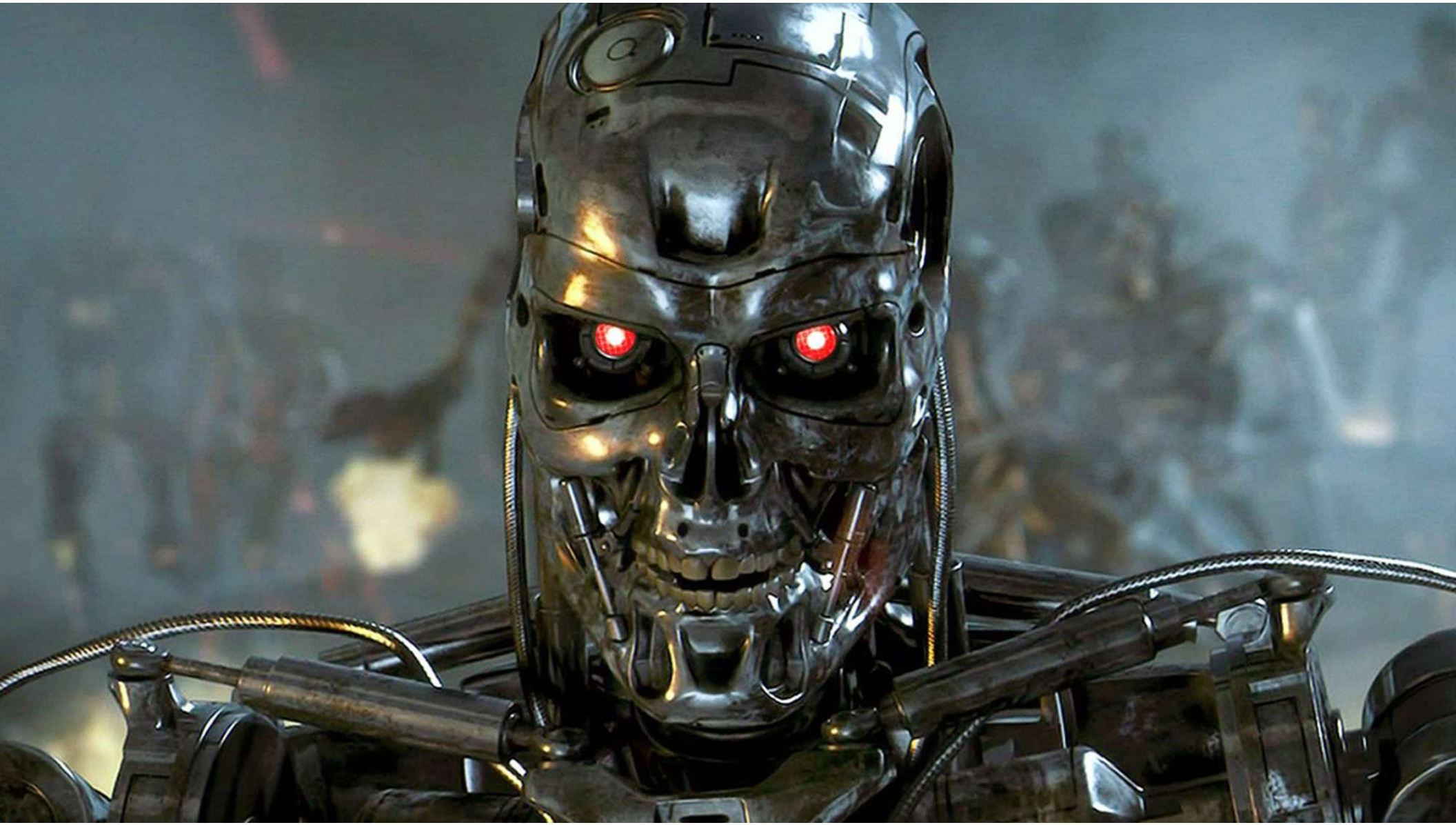
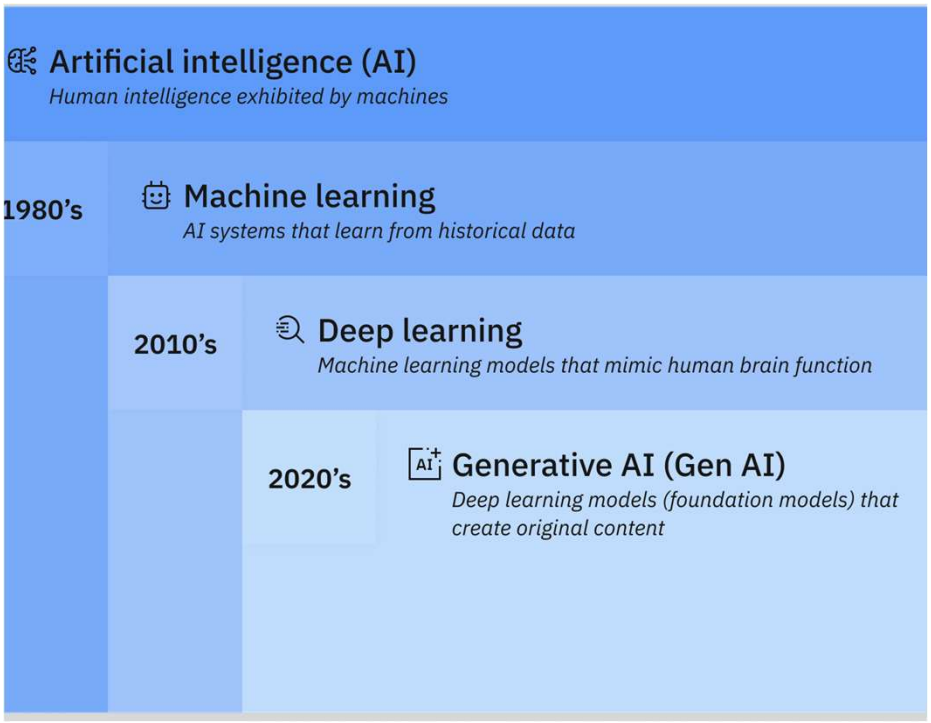


What Is Artificial Intelligence (AI)?

Machine Learning



- Algorithm that makes predictions or decisions based on data
- One or Two hidden input layers
- Supervised learning
  - Utilizes labeled data inputs
- Types
  - Linear regression
  - Logistic regression
  - Decision trees
  - Random forest
  - Support vector machines
  - K-nearest neighbor

https://www.ibm.com/topics/artificial-intelligence

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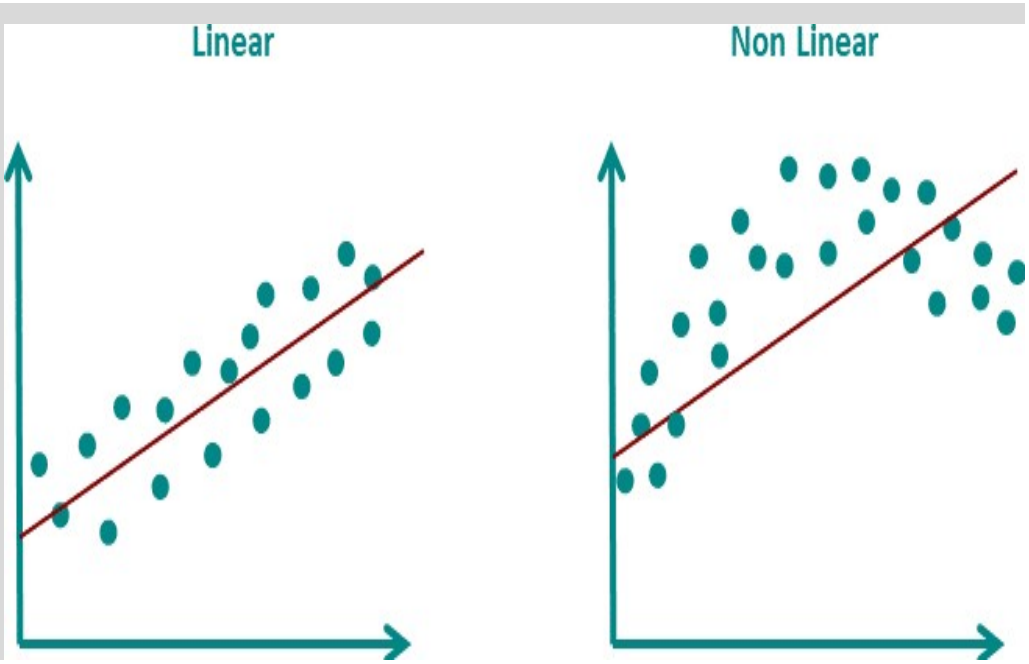
Linear Regression



- Predicts a variable based on the value of another variable
- When x does y it always produces z

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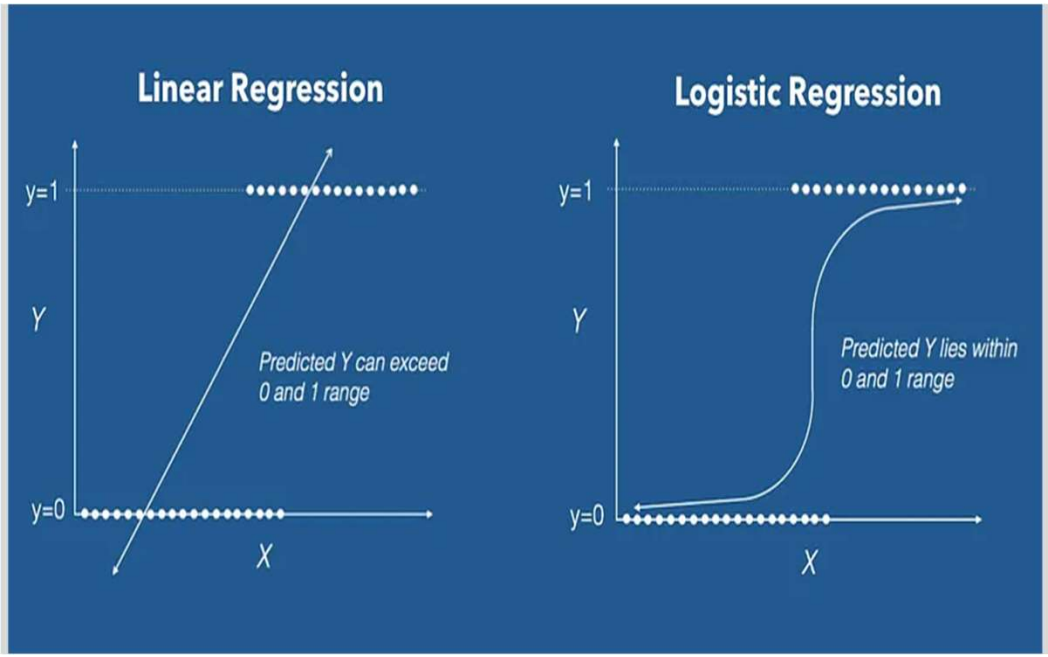
Logistic Regression

- Estimates the probability of an event occurring based on a given data set of independent variables
- Differs from linear regression by predicting a categorical variable versus a continuous one
- When x does y sometimes it produces Z within certain upper and lower parameters



https://www.ibm.com/topics/logistic-regression

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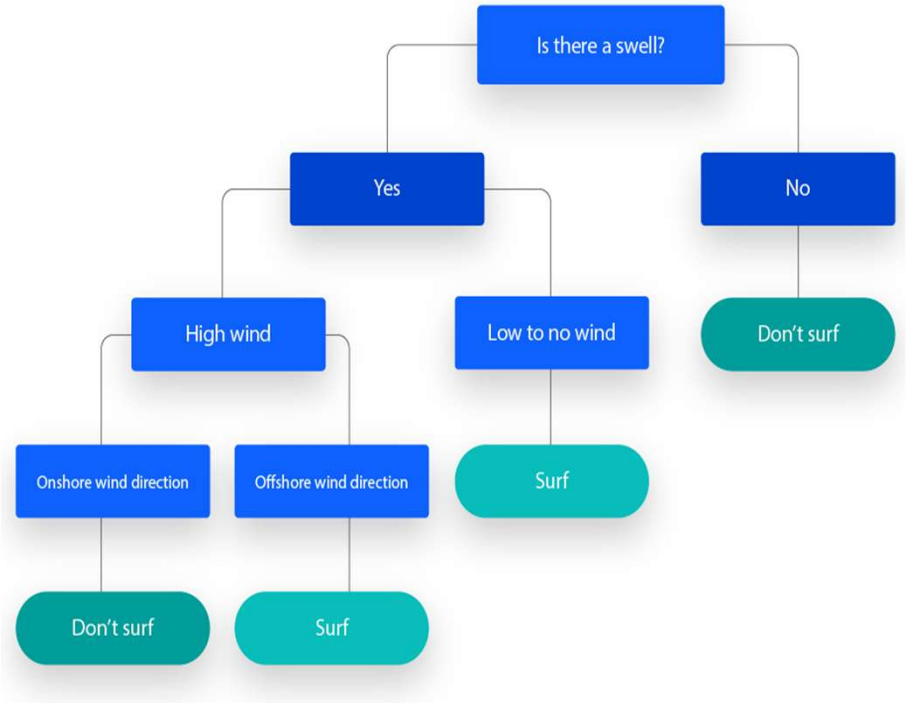
Decision Trees



- A decision tree is a flowchart-like diagram that helps visualize the potential outcomes of a series of decisions.
- Commonly used ACLS, NRP, PALS

https://www.ibm.com/topics/decision-trees

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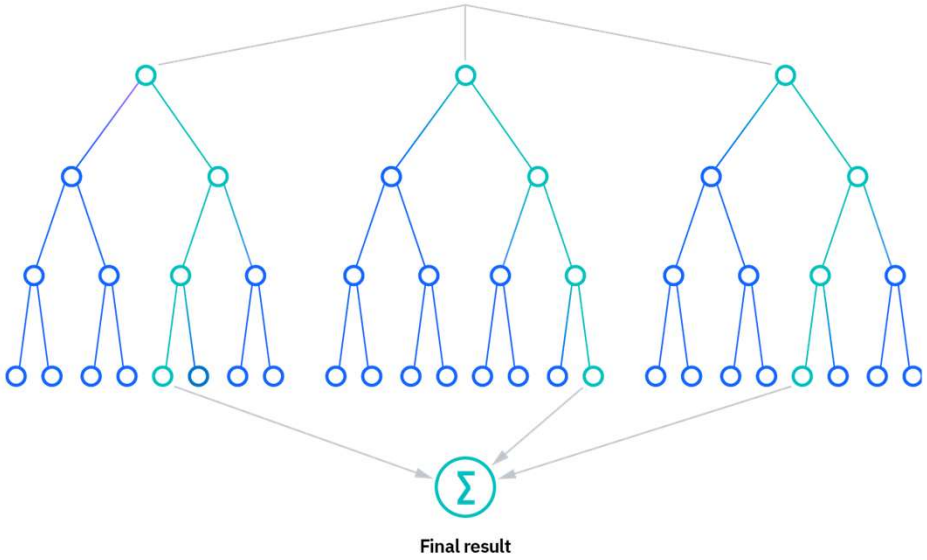
Random Forest

- Utilizes multiple decision trees at once to reach a single result
- Handles both classification and regression problems



https://www.ibm.com/topics/random-forest

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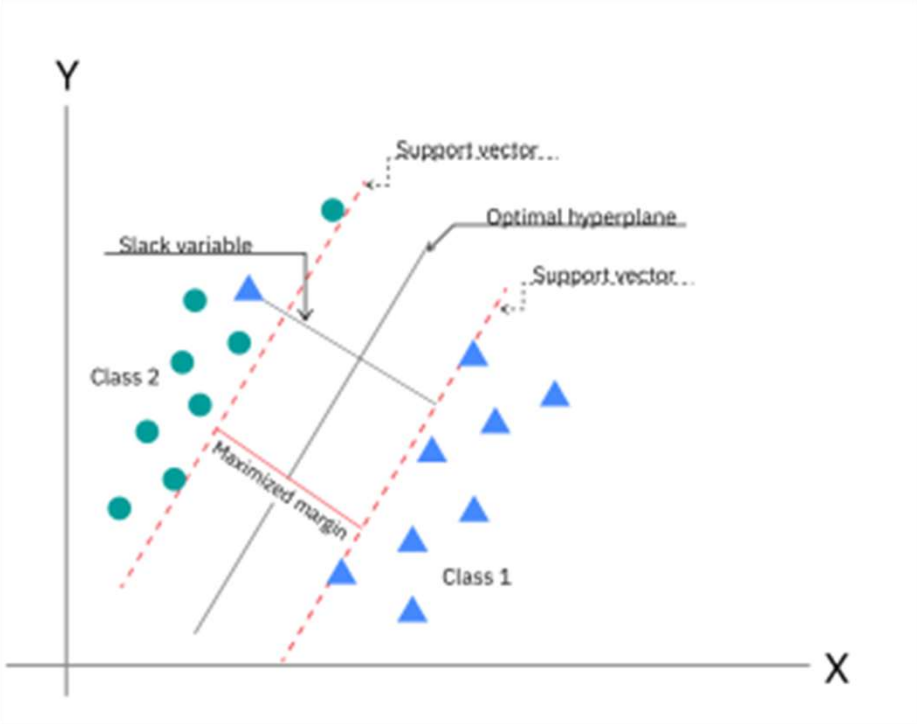
Support Vector Machine (SVM's)



- A machine learning algorithm that classifies data by finding the best hyperplane to separate it into classes
- Commonly utilized in detecting spam emails

https://www.ibm.com/topics/support-vector-machine

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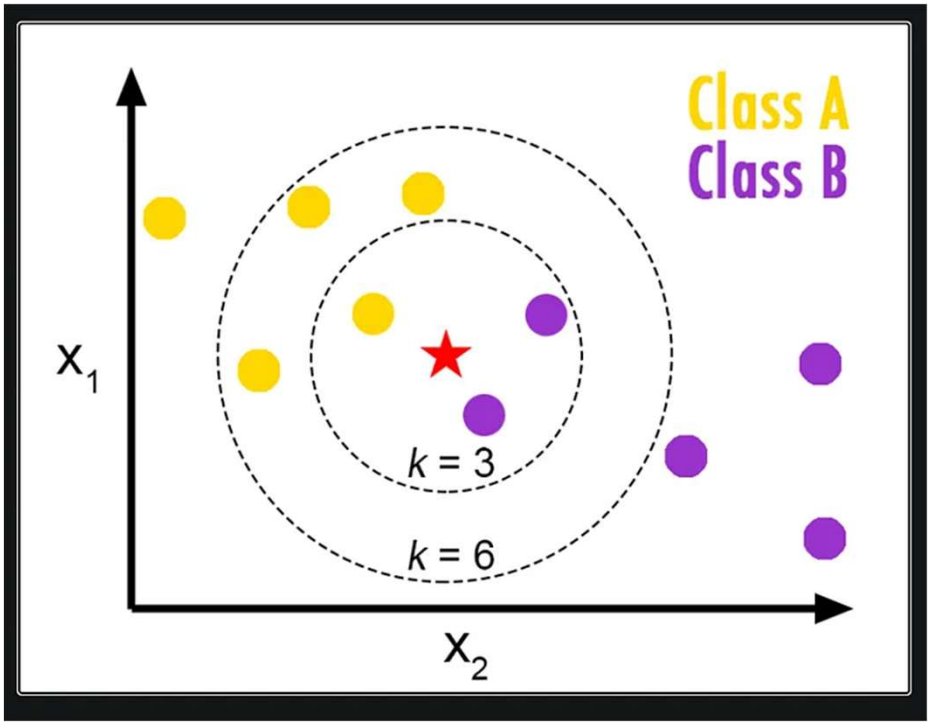
K-Nearest Neighbors

- The data-point is classified on the basis of its k Nearest Neighbors
- This is followed by the majority vote of those nearest neighbors



https://ai.plainenglish.io/introduction-to-k-nearest-neighbors-knn-algorithm-e8617a448fa8

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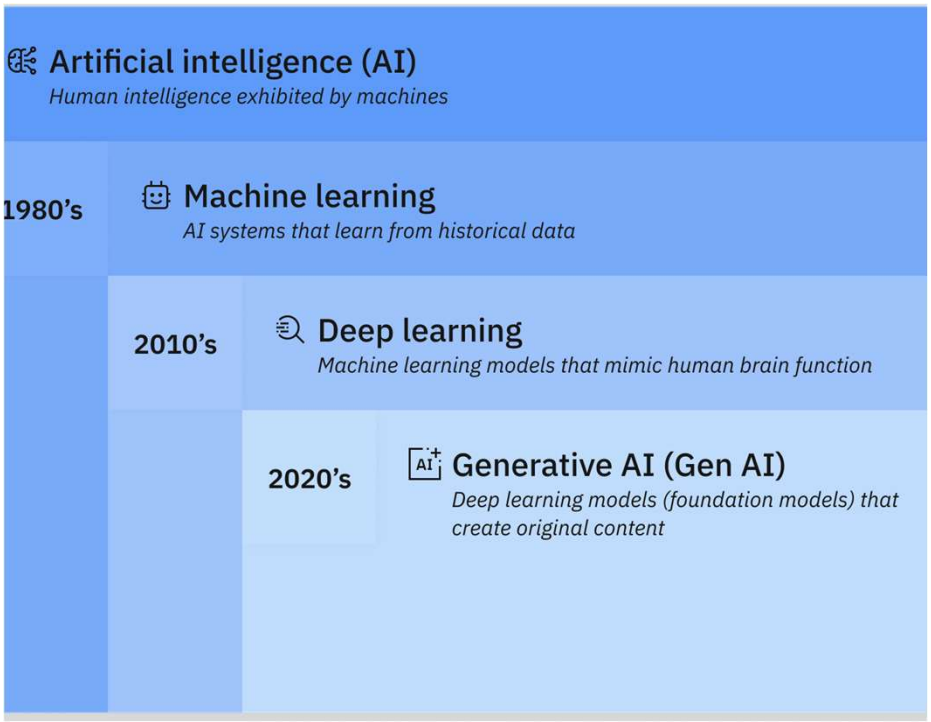
Deep Learning



- Subset of Machine Learning that utilize three to hundreds of input layers
- More closely simulates complex decision making power of the human brain
- Enables unsupervised learning
  - Utilizes unlabeled data input
  - Can make their own predictions of what the data represents

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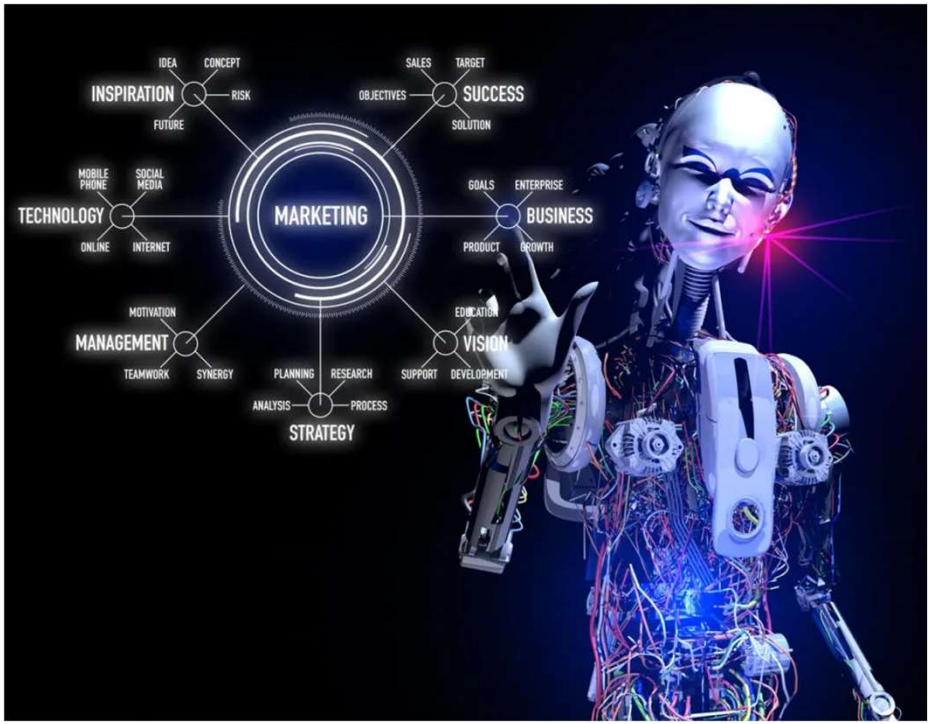
Deep Learning Uses



- Targeted marketing
  - Making recommendations based on previous product searches and purchases
  - Utilizes search histories, content consumption such as streaming, reading, and listening habits

https://medium.com/@hussain161620/the-evolution-of-digital-marketing-embracing-the-ai-revolution-for-sustainable-growth-db2b3f5102cb

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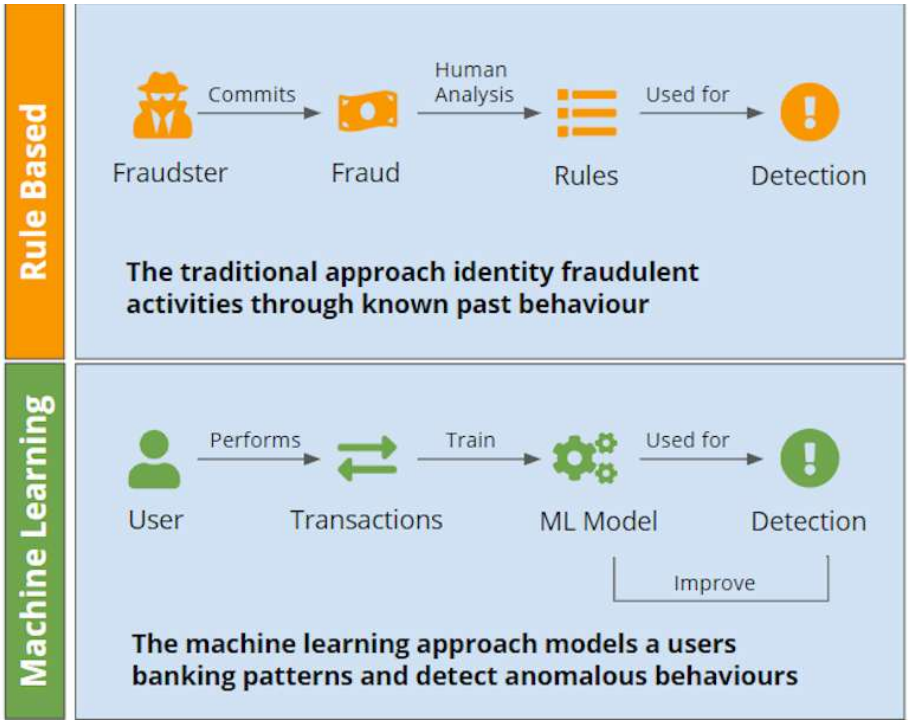
Deep Learning Uses

- Fraud Detection
  - Uses spending patterns and proximity to detect fraud
  - Constantly learning from previous spending patterns to predict future patterns and identify aberrations



https://www.cylynx.io/blog/machine-learning-for-fraud-detection/

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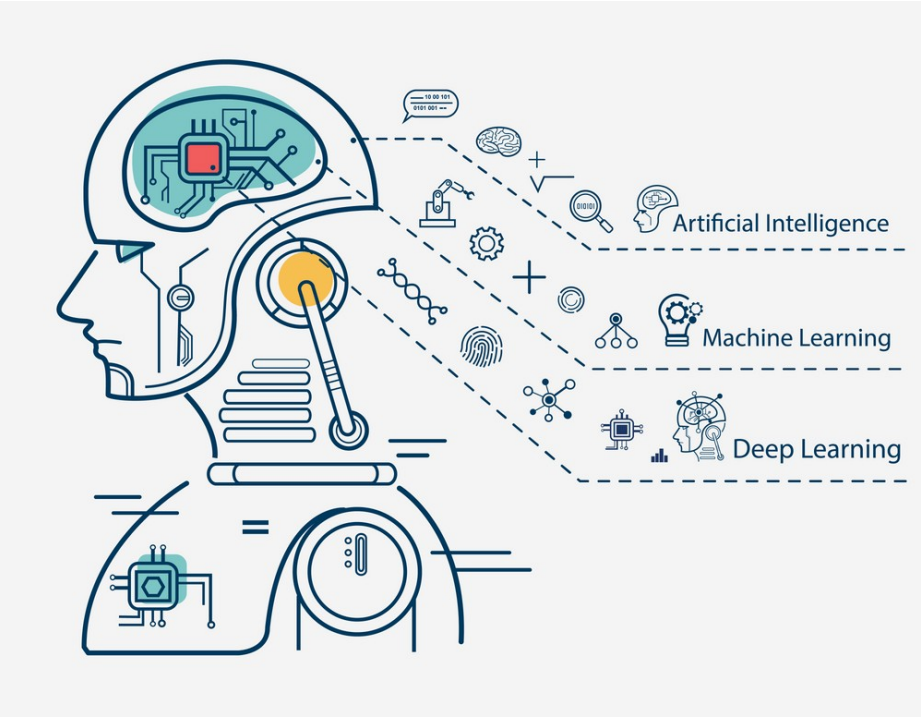
Generative AI

- Simulates behavior of the human brain
- Teaches computers to learn from examples such as
  - Image identification
  - Language translation
  - Pattern recognition
  - Decision making



https://www.neurond.com/blog/10-applications-of-deep-learning-in-artificial-intelligence

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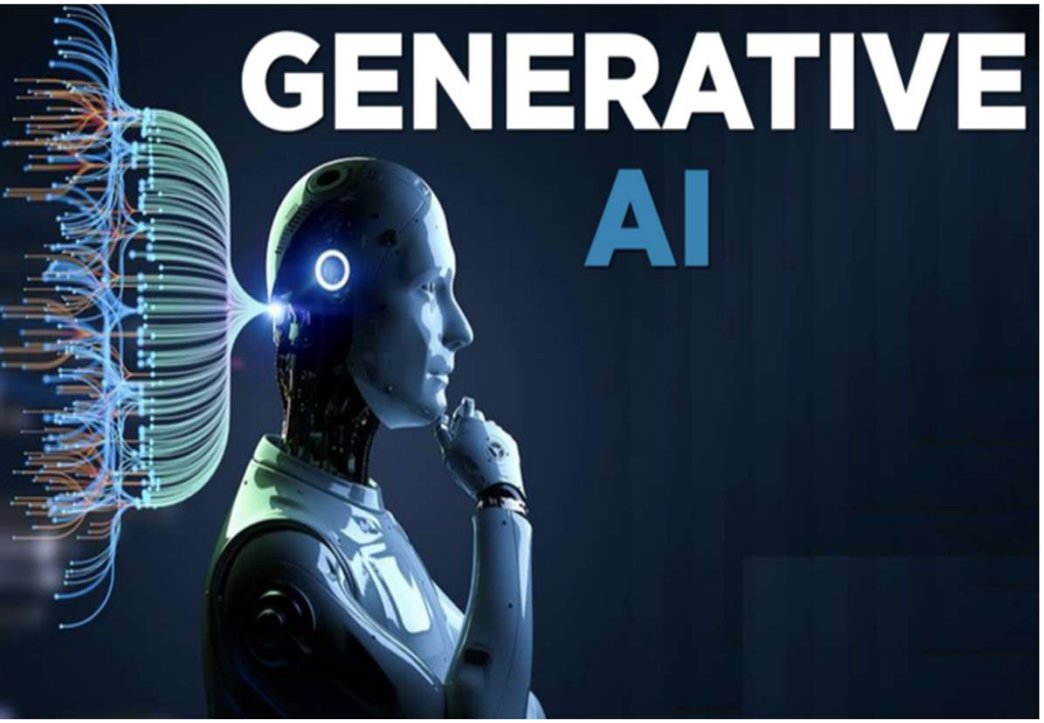
Generative AI



- Deep learning models that can create complex original content
- Draw from their training data to create new work that's similar but not identical

https://www.ibm.com/topics/artificial-intelligence

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Generative AI

- Evolved to analyze and generate more complex data types
  - Variational Autoencoders (VAE's)
    - Generates multiple variations of content in response to a prompt
  - Diffusion Models
    - Add then remove "noise" to images to generate original images in response to prompts
  - Transformers
    - Generate extended sequences of content
    - Core of popular AI tools

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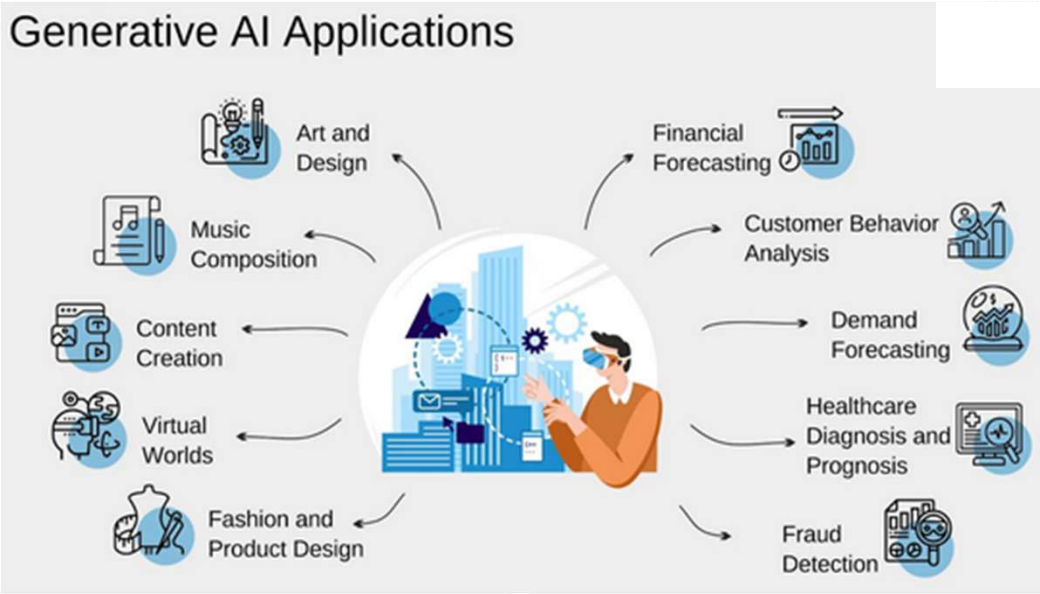
Generative AI

- How it works
  - Training
  - Tuning
  - Generation evaluation and more tuning
- Benefits
  - Automation of repetitive tasks
  - More and faster insight from data
  - Fewer human errors
  - 24x7 availability



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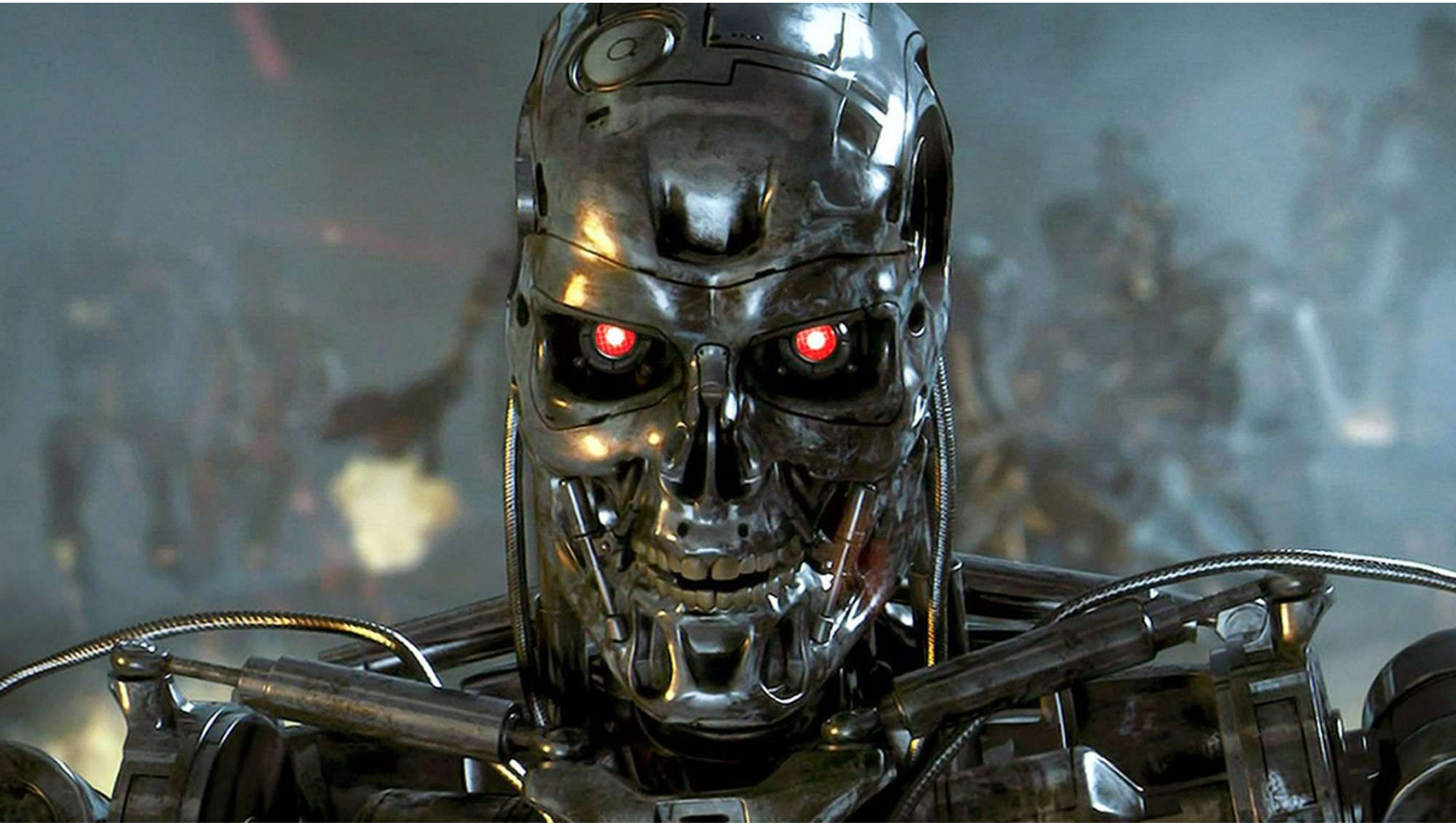

AI In Healthcare

Diagnostics

- Radiology
  - Deep Learning allows AI identification of myriad maladies via
    - X-Ray
    - CT Scan
    - MRI
    - PET Scan

https://health.clevelandclinic.org/ai-in-healthcare

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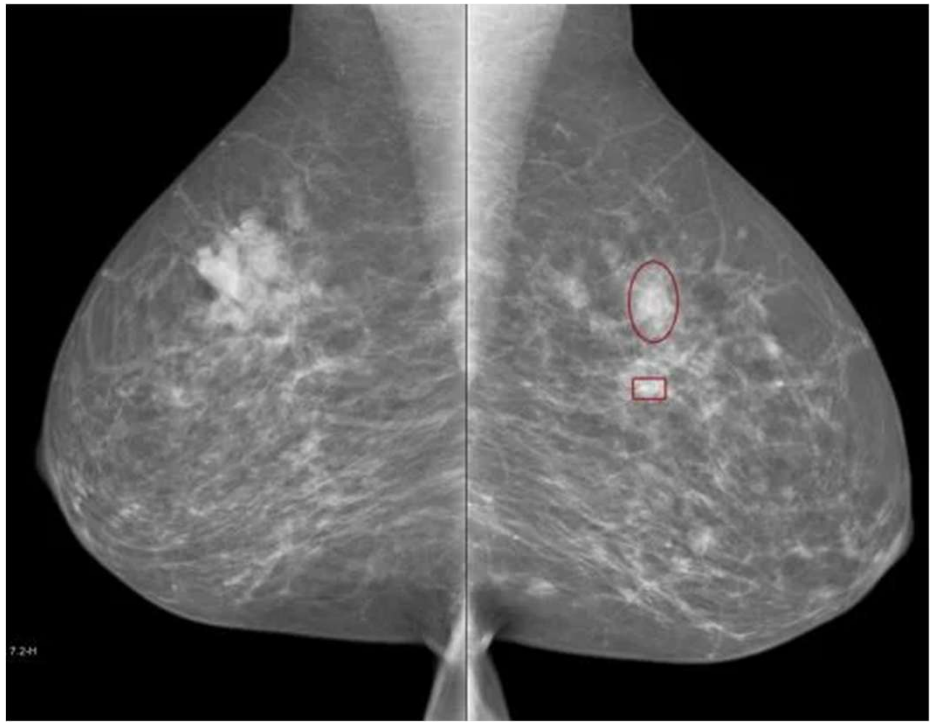
Breast Cancer

- ProFound AI
  - Compares mammography against a learned dataset to pinpoint and circle areas of concern
  - Delivers a confidence level numeric as well
  - FDA approved



https://health.clevelandclinic.org/ai-in-healthcare

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Stroke

- Viz.ai
  - Reviews scans of potential stroke at time of scan
  - Mobilizes resources and schedules procedures
  - Improves efficiency and timeliness of stroke treatment

https://health.clevelandclinic.org/ai-in-healthcare

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Drug Discovery

- Helps designs Drugs
- Predicts side effects
- Identifies ideal candidates for clinical trials
- Pfizer utilized AI to develop a Covid-19 treatment
  - Paxlovid

https://builtin.com/artificial-intelligence/artificial-intelligence-healthcare#:~:text=What%20Is%20AI%20in%20Healthcare,more%20timely%20and%20personalized%20treatments.

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Home Care

- Biofourmis
  - Utilizes AI with smartphones and wearables to monitor patients at home
  - Messages patients when needed
  - Conducts virtual visits
  - Assists in earlier hospital discharge

https://builtin.com/artificial-intelligence/artificial-intelligence-healthcare#:~:text=What%20Is%20AI%20in%20Healthcare,more%20timely%20and%20personalized%20treatments.

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General Screenings

- Freenome
  - Uses AI in general screenings including
    - Diagnostic tests and blood work
    - Tests for cancer

https://builtin.com/artificial-intelligence/artificial-intelligence-healthcare#:~:text=What%20Is%20AI%20in%20Healthcare,more%20timely%20and%20personalized%20treatments.

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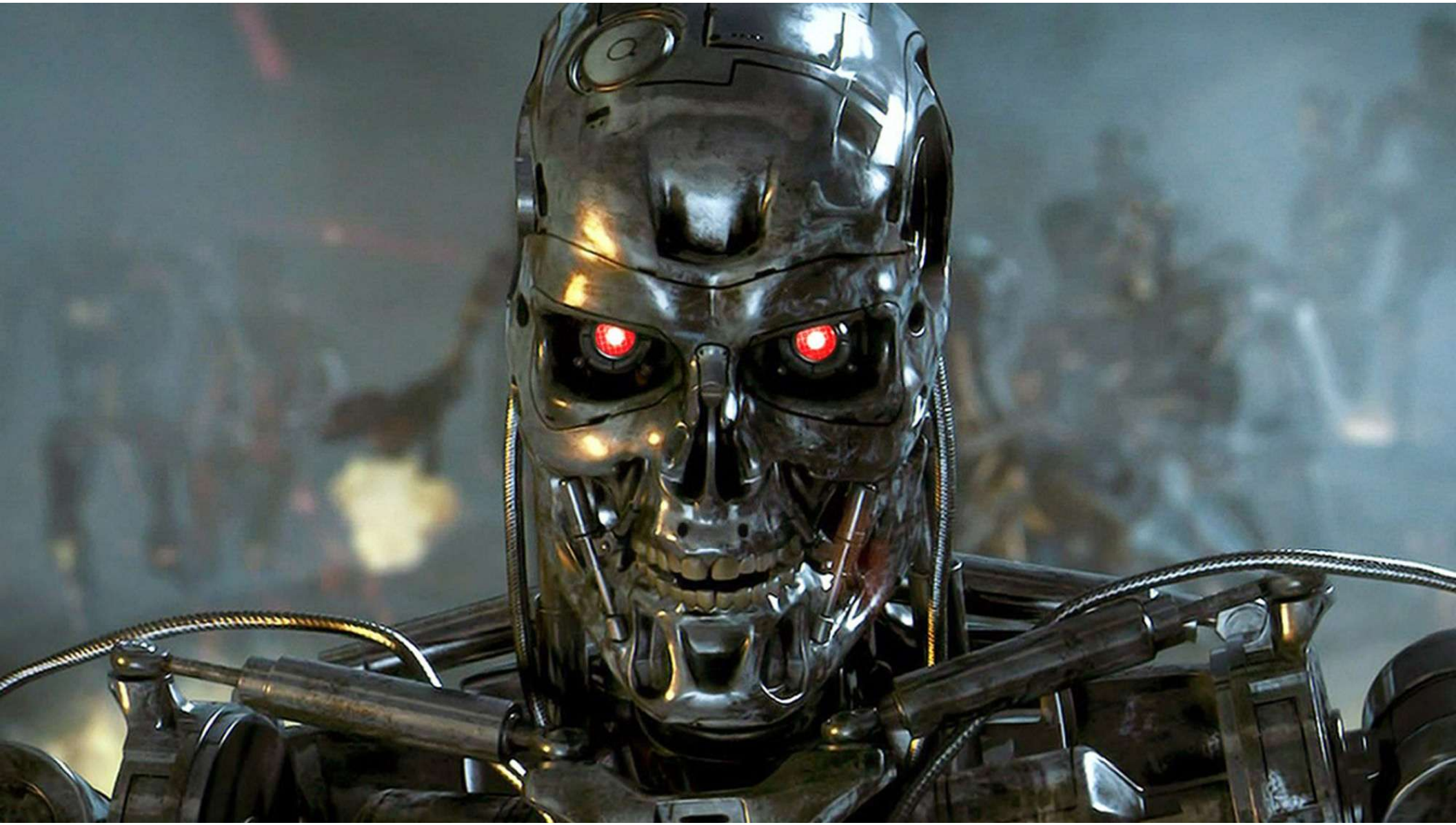

IBM

- Utilizes Jeopardy winning Watson AI
  - Improves treatment
  - Patient engagement
  - Develops personalied health plans
  - Interpreting genetic testing results
  - Catching early signs of disease

https://builtin.com/artificial-intelligence/artificial-intelligence-healthcare#:~:text=What%20Is%20AI%20in%20Healthcare,more%20timely%20and%20personalized%20treatments.

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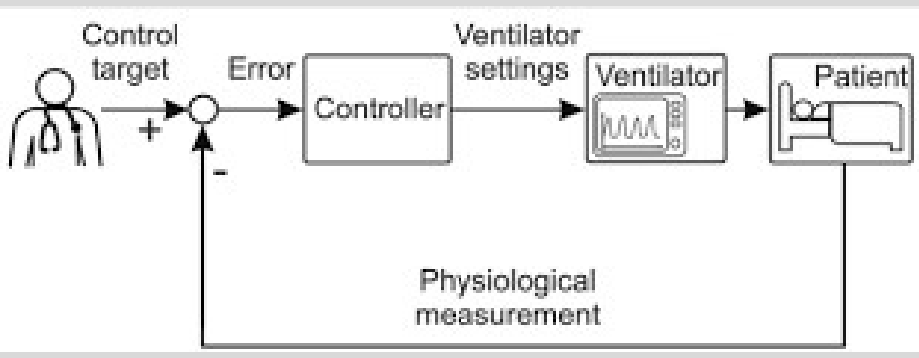
AI in Mechanical Ventilation

Closed Loop Ventilation



- Uses Machine Learning functionality
  - Adaptive Support Ventilation (ASV)
    - Hamilton Medical Inc.
  - Adaptive Ventilation Mode (AVM)
    - Vyaire

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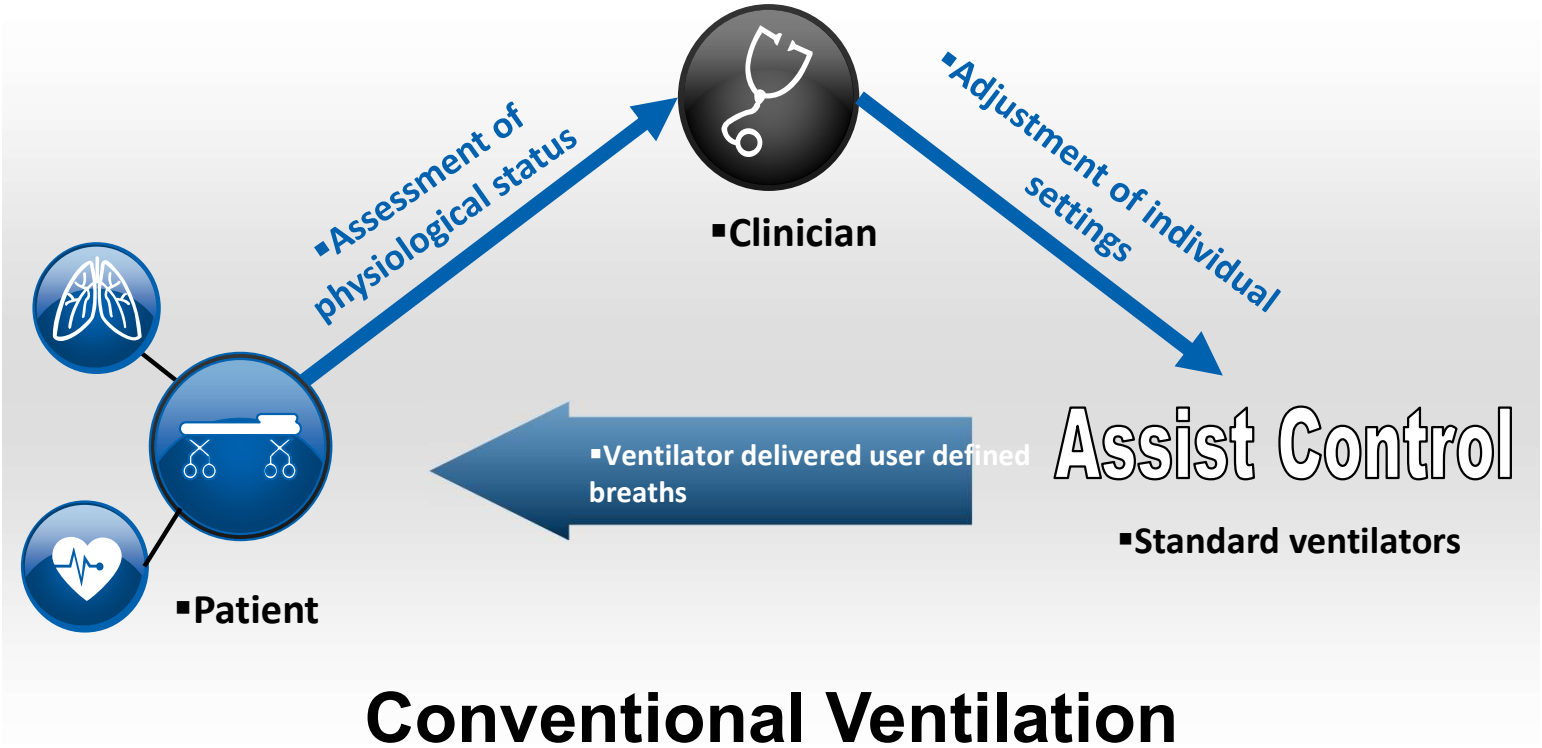
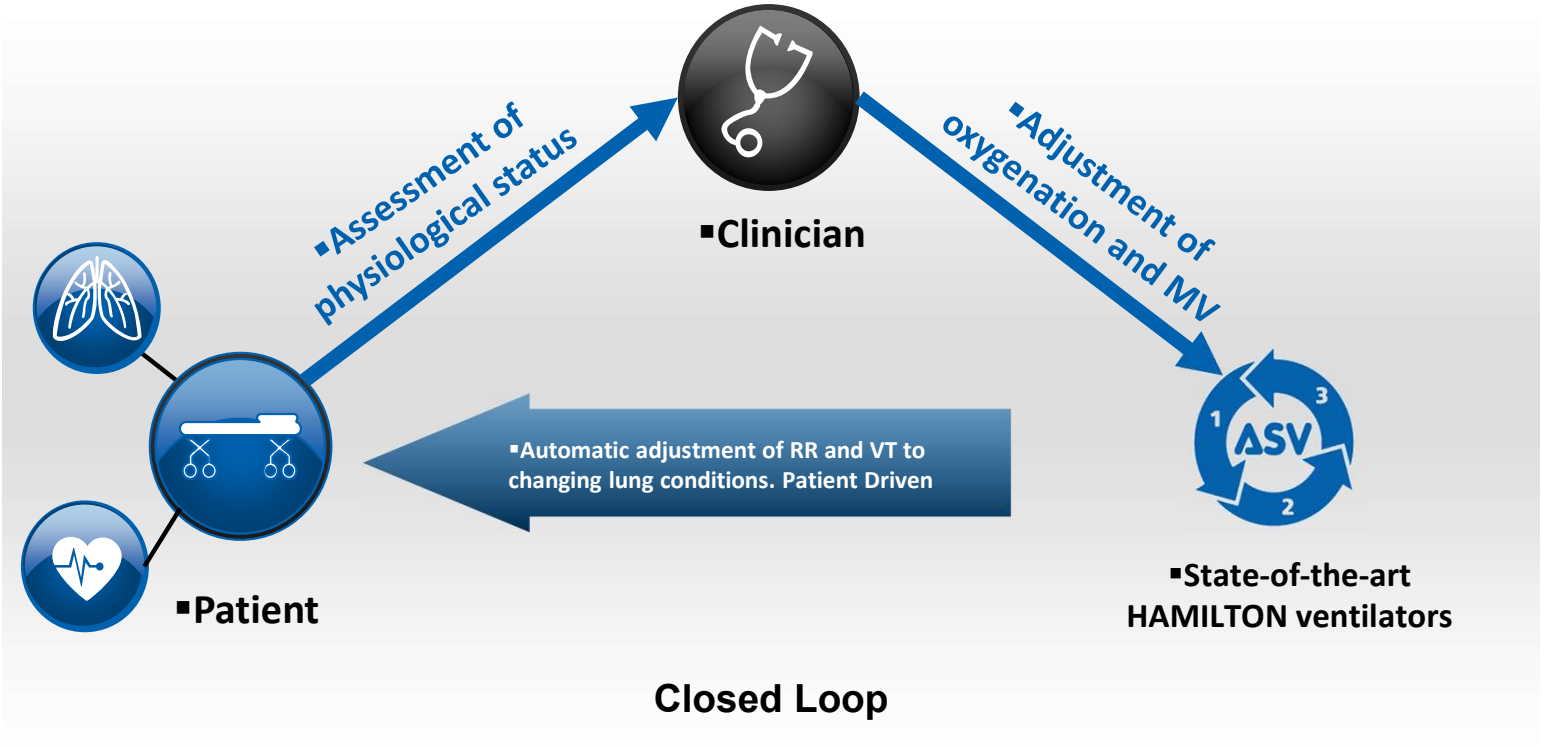
Improved Patient Outcomes



Conventional Ventilation

Improved Patient Outcomes



Closed Loop

Intelligent Ventilation

ASV

Patient Driven Ventilator Management

‘Optimal Closed Loop Control’:

- Automation of patient derived pulmonary mechanics
  - identification of optimal/least WOB/least stress
  - the optimal f/Vt
- No more mode fights *(uncertainty about which is “best”)*
- Full, partial and weaning support
- A paradigm change predicated on evidenced based medicine and accepted clinical practices.....

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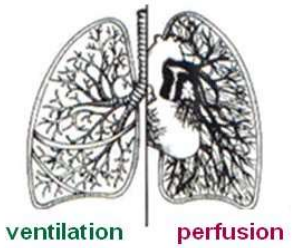
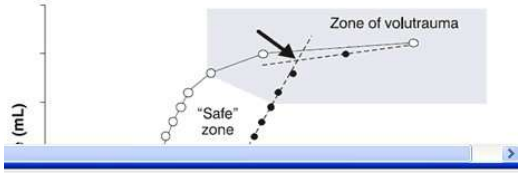
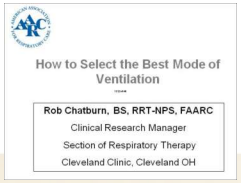
Our Objectives?

What Are the Goals of Ventilation?

- **Do no harm (promote safety)**
  - Provide adequate gas exchange
    - *Optimize $\dot{V}/\dot{Q}$ relation*
  - Protect the lung
    - *Optimize P/V relation*
- **Promote patient comfort**
  - *Optimize WOB_{vent} vs $WOB_{patient}$*
- **Liberate as soon as possible**
  - *Optimize weaning experience*







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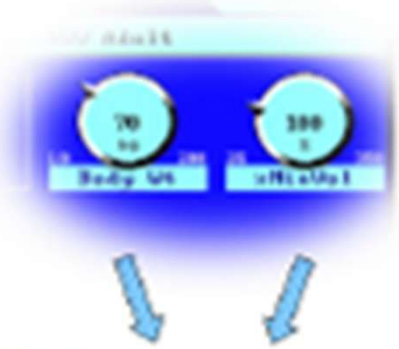
ASV

- ASV is an easy-to-use closed loop mode of ventilation designed to maintain goal-directed mechanical ventilation using a Lung Protective Strategy
- ASV streamlines the set-up, maintenance, and weaning of the mechanical ventilator
- Ventilation targets are derived from analysis of the patients pulmonary mechanics and are automatically implemented
- All delivered breaths are volume targeted pressure controlled, flow variable breaths

•Mandatory breaths are delivered with pressure control & time cycled
•Spontaneous breaths are delivered with pressure support & flow cycled

How does PATIENT ORIENTED Intelligent Ventilation work?

Dr. A.B. Otis



$$f\text{-target} = \frac{1+2a*RC_{exp}*(MV-V'D)/VD - 1}{a*RC_{exp}}$$

For any combination of resistance, compliance, V'a and Vd, there is a respiratory rate where WOB is minimal

Otis AB, Fenn WO, Rahn H, Mechanics of breathing in man, JAP 1950; 2: 592-607

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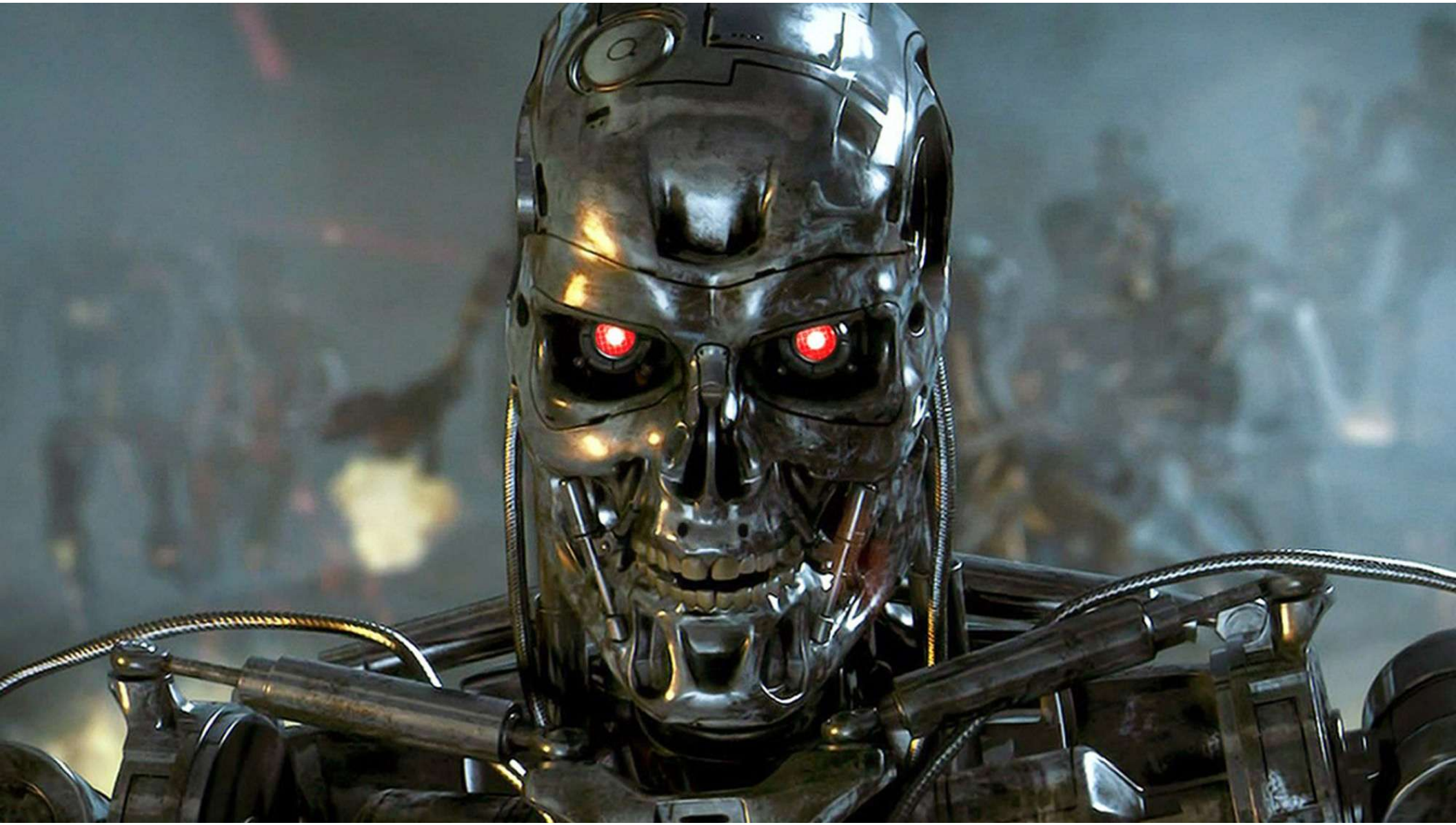
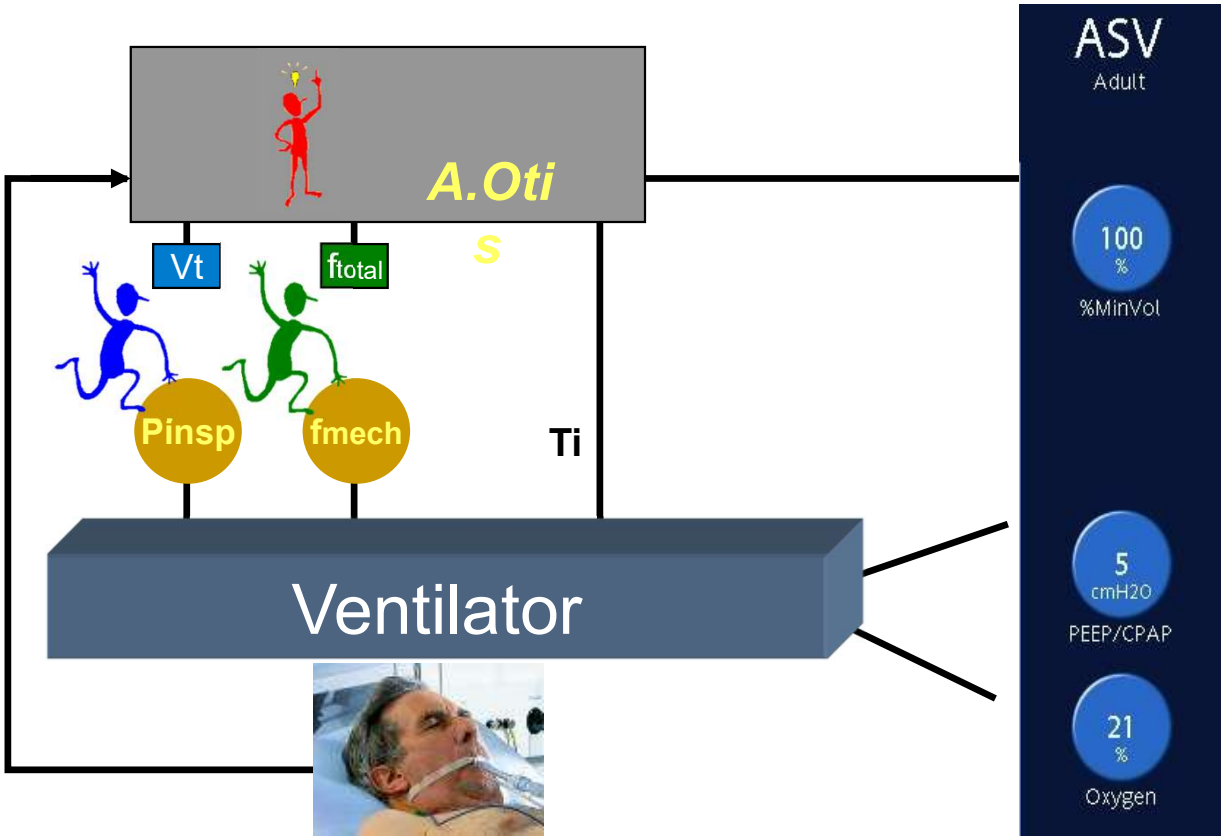
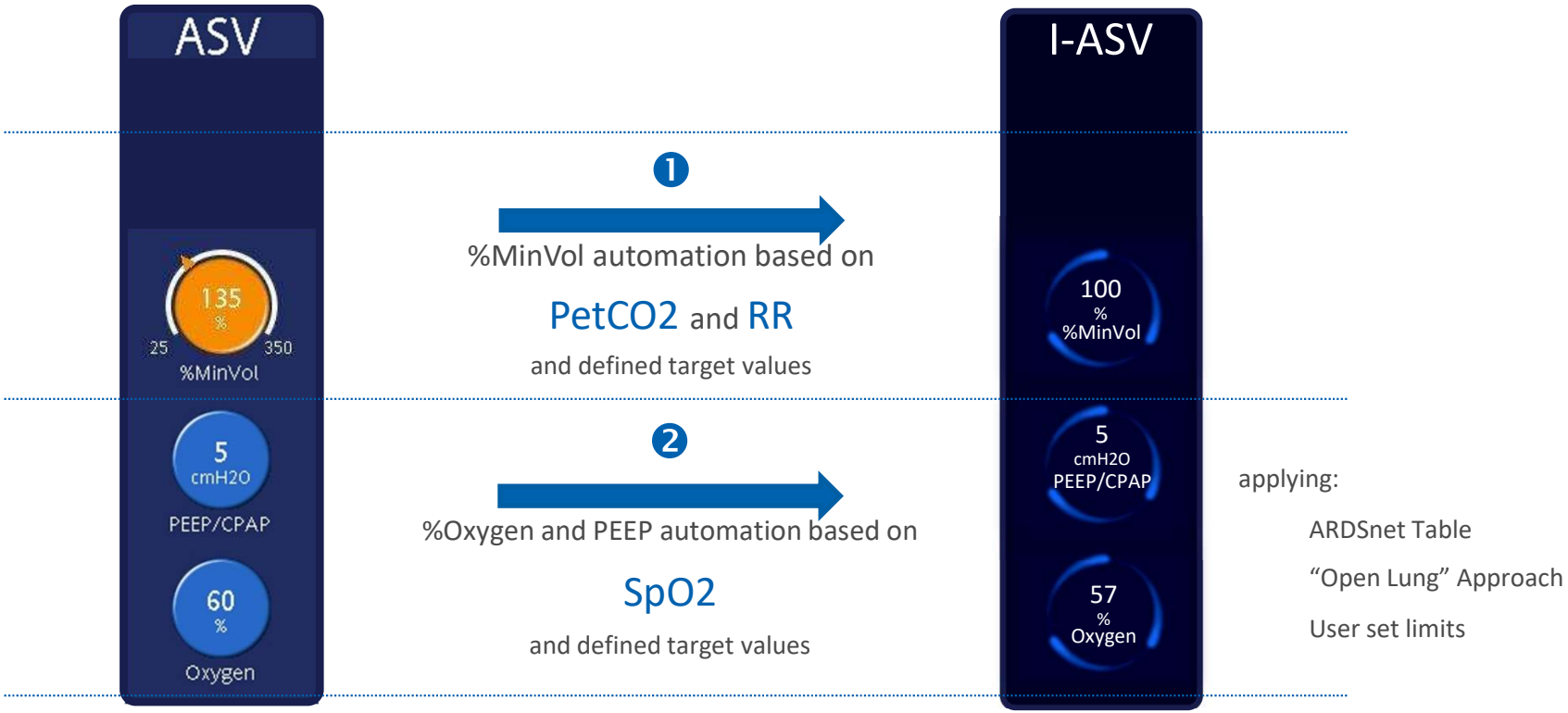


How does ASV work?



INTELiVENT-ASV



Ventilation controller

set by clinician

Patient type, gender & height

Patient condition
(ARDS, Brain Injury, Chronic Hypercapnia)

PetCO2 target range

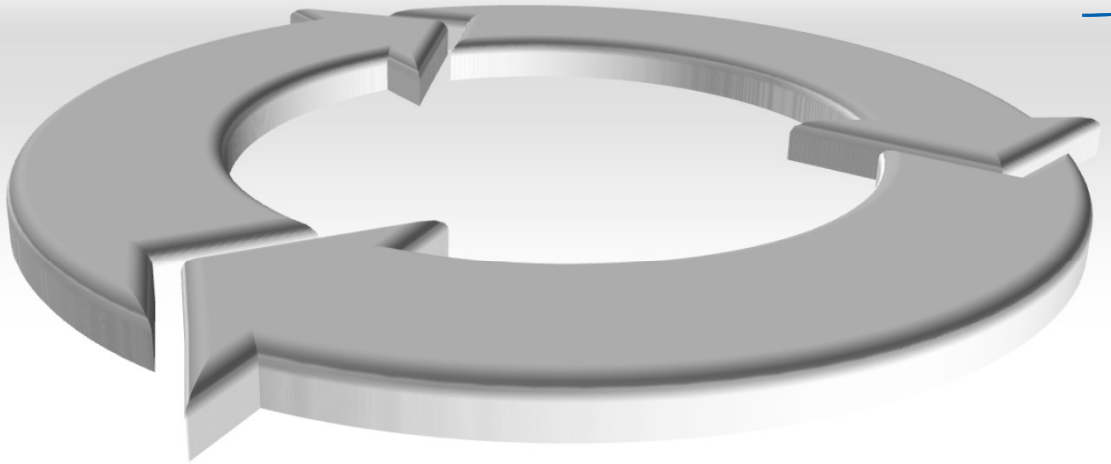
P_{ASV} limit

PetCO2

RCexp

***f*Spont & V_T**

from patient
breath by breath



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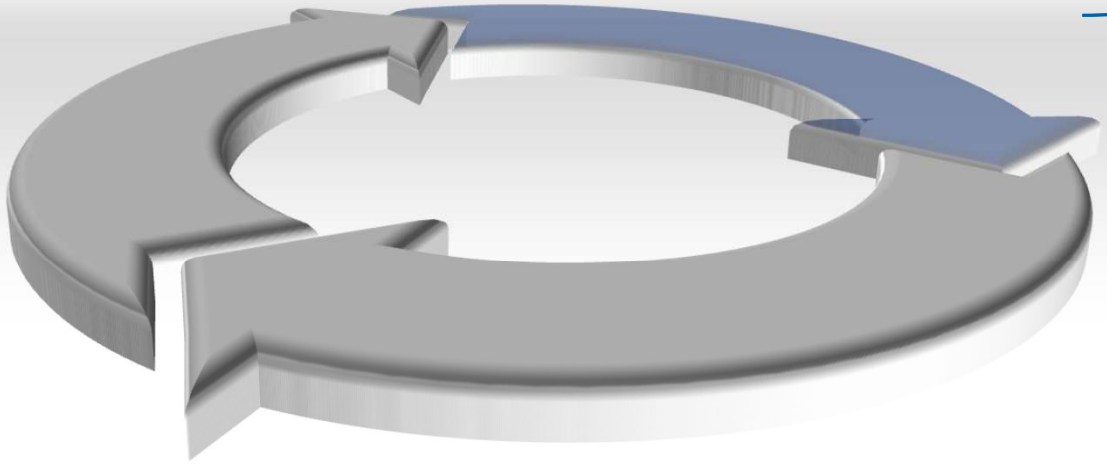


Automatically
adapts %MinVol

Ventilation controller

set by clinician

Patient type, gender & height

Patient condition
(ARDS, Brain Injury, Chronic Hypercapnia)

PetCO2 target range

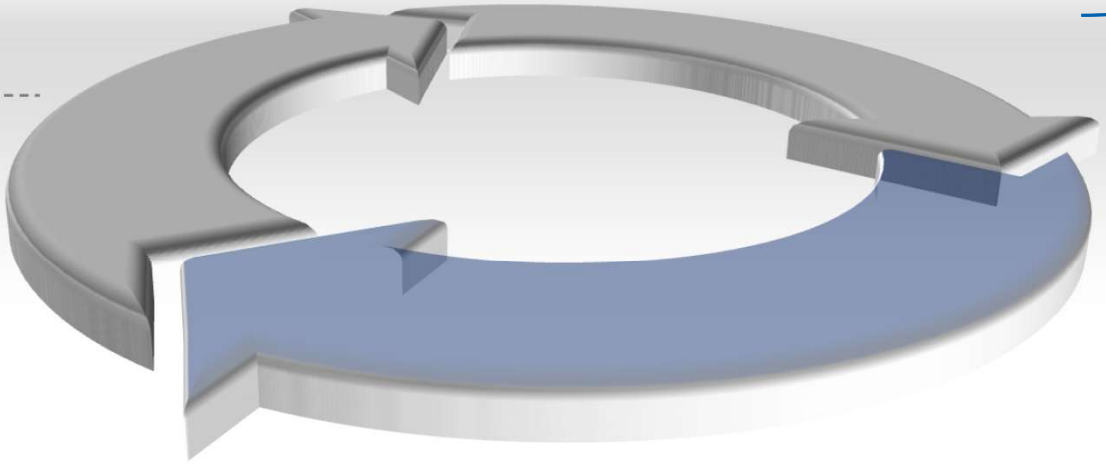
PASV limit

PetCO2

RCexp

***f*Spont & VT**

from patient
breath by breath



Achieve target PetCO2
(or target RR*)

Automatically
adapts %MinVol

*in spontaneously breathing patients
when PetCO2 is within the user-defined target (+ 3mmHg)

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Intelligent Ventilation since 1983

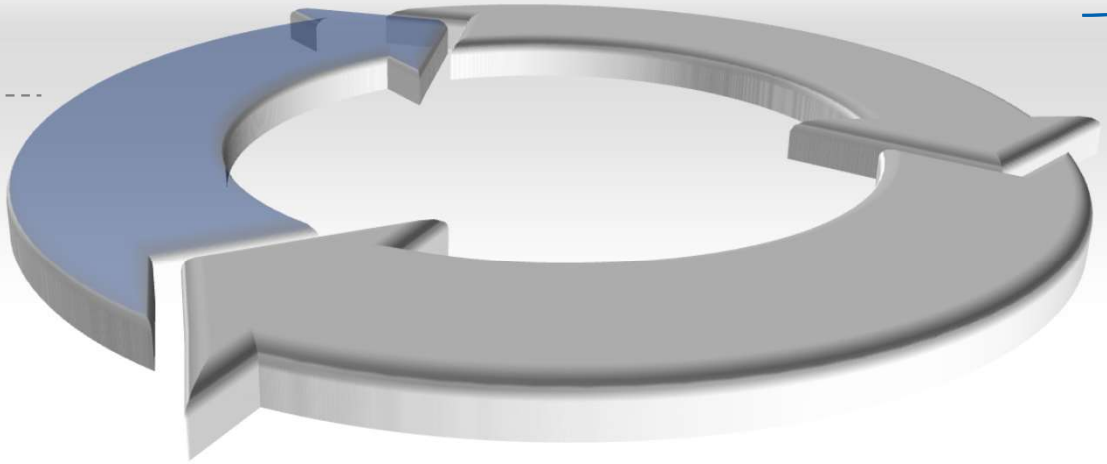
Ventilation controller

set by clinician

- Patient type, gender & height
- **Patient condition**
  (ARDS, Brain Injury, Chronic Hypercapnia)
- **PetCO2** target range
- **PASV limit**

from patient
breath by breath

- **PetCO2**
- **RCexp**
- ***f*Spont & VT**



Achieve target PetCO2
(or target RR*)

Automatically
adapts %MinVol

*in spontaneously breathing patients
when PetCO2 is within the user-defined target (+ 3mmHg)

Oxygenation controller

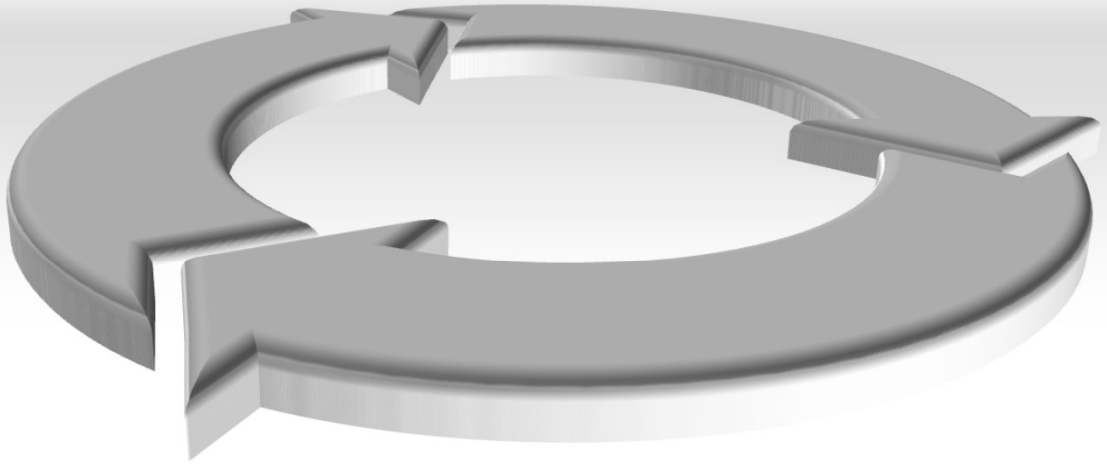
set by clinician

Patient condition
(ARDS, Brain Injury, Chronic Hypercapnia)

SpO2 target range

PEEP limit (Min & Max)

Minimum FiO2 (0.21 - 0.30)



SpO2

HLI*

from patient

HLI* heart-lung interaction index, when enabled, it is used to define the upper PEEP limit. HLI is available only with a Nihon Kohden pulse oximeter.

Oxygenation controller

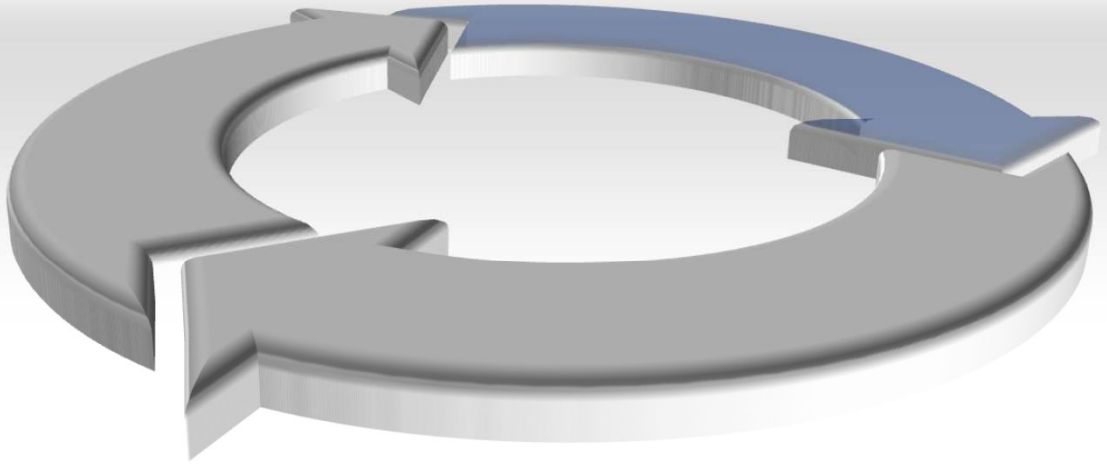
set by clinician

Patient condition
(ARDS, Brain Injury, Chronic Hypercapnia)

SpO2 target range

PEEP limit (Min & Max)

Minimum FiO2 (0.21 - 0.30)



SpO2

HLI*

from patient

Automatically adapts %Oxygen and PEEP level

Oxygenation controller

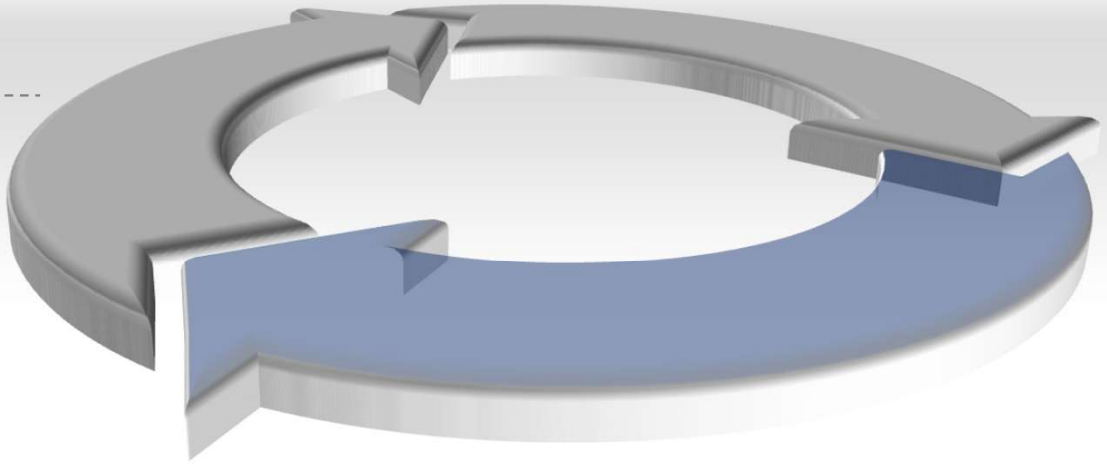
set by clinician

- **Patient condition**
  (ARDS, Brain Injury, Chronic Hypercapnia)
- **SpO2** target range
- **PEEP limit** (Min & Max)
- **Minimum FiO2** (0.21 - 0.30)

SpO2

HLI*

from patient



Achieve user set **target SpO2**

Automatically adapts %Oxygen and PEEP level

*Brower RG. N Engl J Med. 2004 Jul 22;351(4):327-36.
*ARDSnet. N Engl J Med. 2000 May;342(18):1301-1308

Oxygenation controller

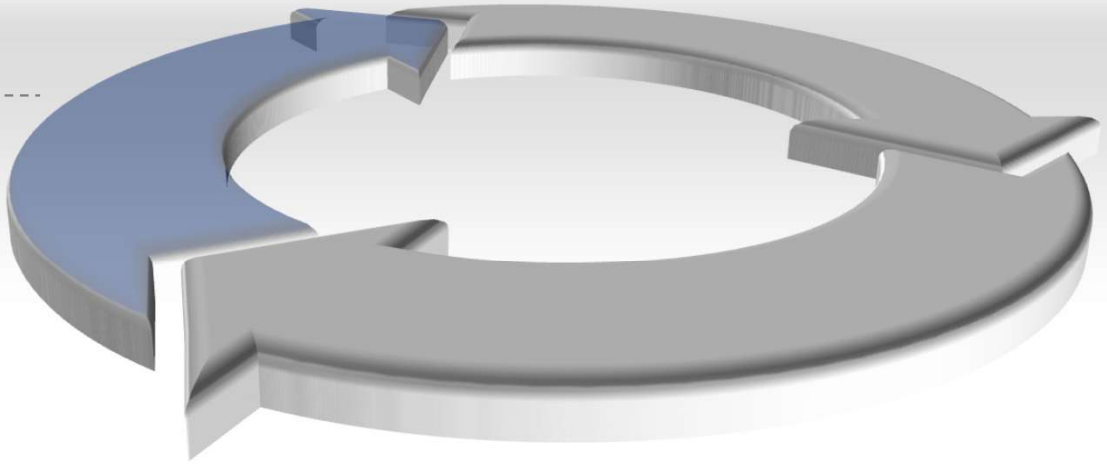
set by clinician

- **Patient condition**
  (ARDS, Brain Injury, Chronic Hypercapnia)
- **SpO2** target range
- **PEEP limit** (Min & Max)
- **Minimum FiO2** (0.21 - 0.30)

SpO2

HLI*

from patient



Achieve user set **target SpO2**

Automatically adapts %Oxygen and PEEP level

*Brower RG. N Engl J Med. 2004 Jul 22;351(4):327-36.
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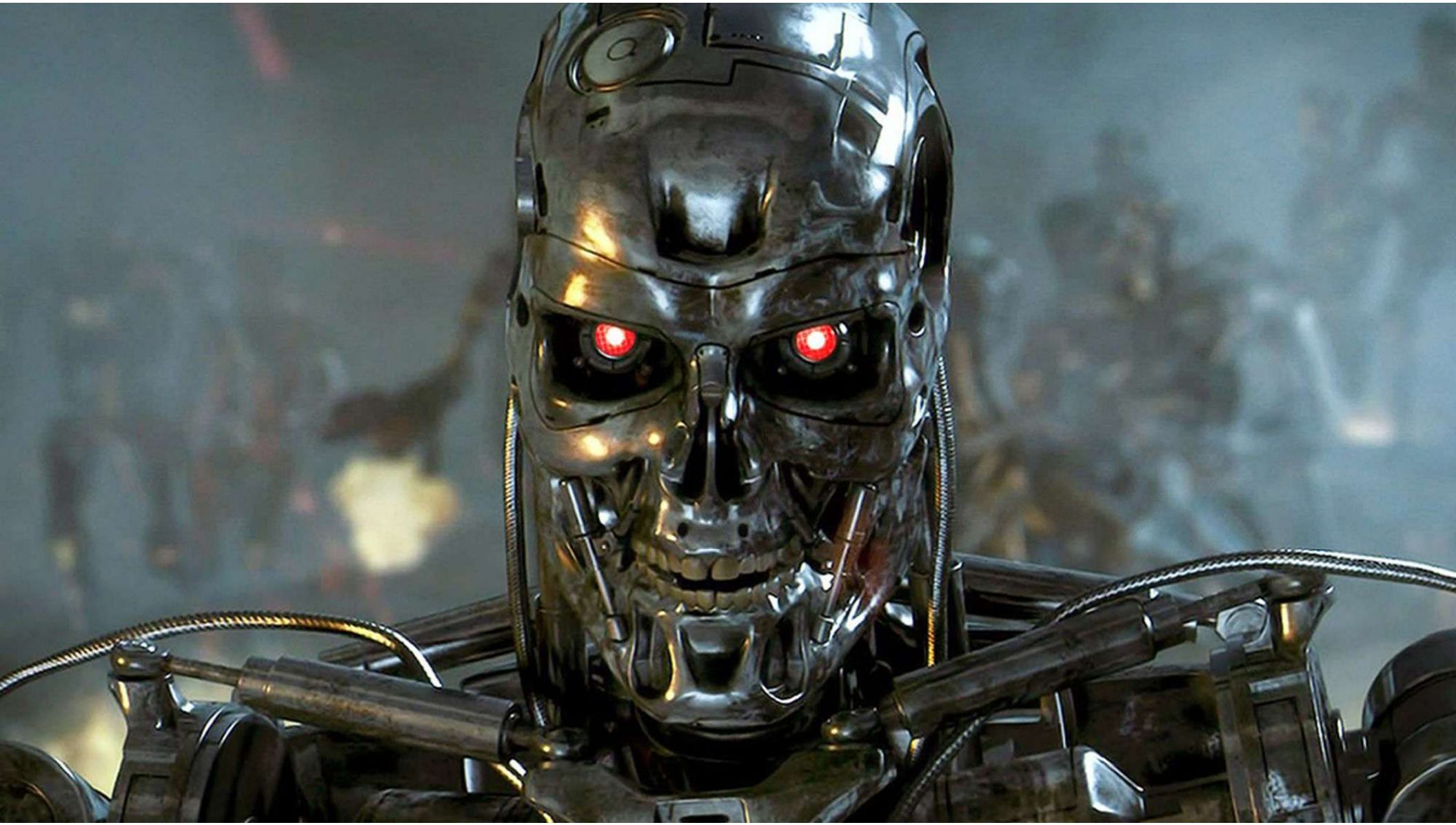
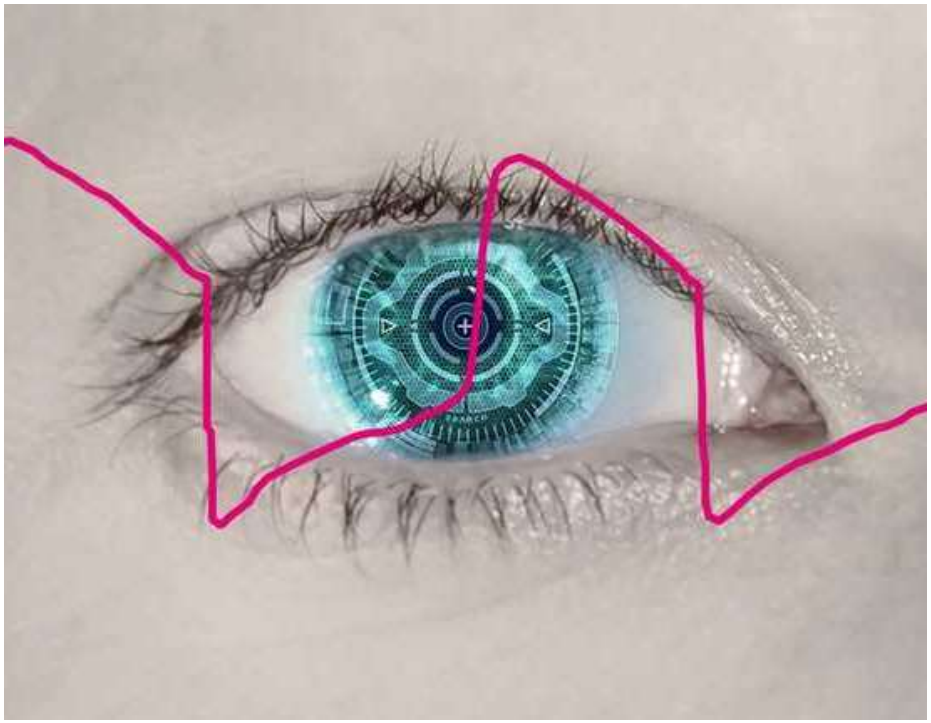


Closed Loop Synchrony



- Deep Learning AI algorithm
  - IntelliSync+
    - Hamilton Medical Inc.
  - Auto.sync
    - Vyaire

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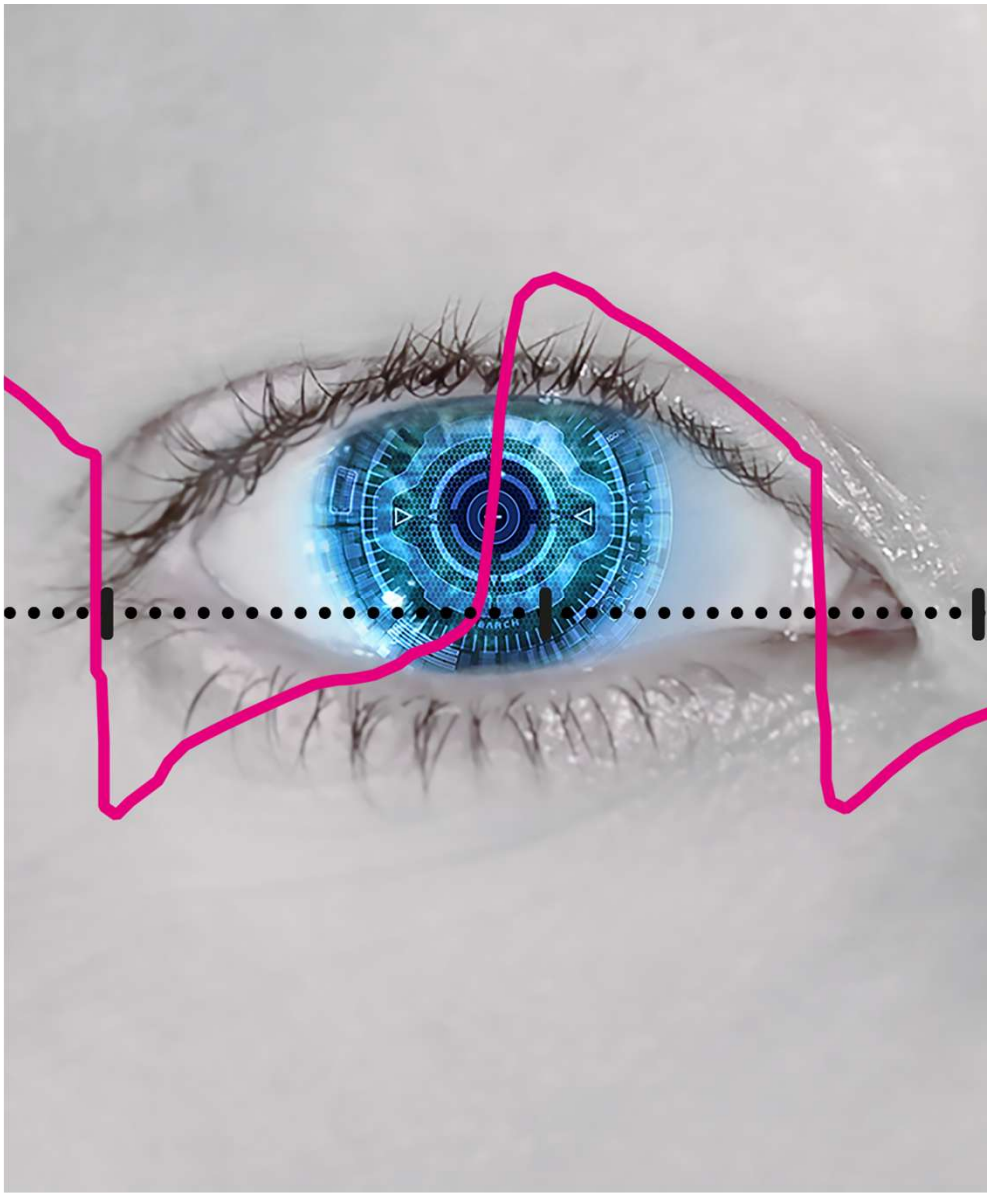
How IntelliSync+ works

- ✓ Mimics the expert‘s eye to identify signs of patient effort (trigger) or relaxation (cycling)
- ✓ Continuously analyzes waveform shapes hundreds of times per second
- ✓ Real-time, in-breath adaptation to changing patient conditions and leaks
- ✓ Patient can trigger even when
  - ✓ flow is still negative
  - ✓ expiration is incomplete

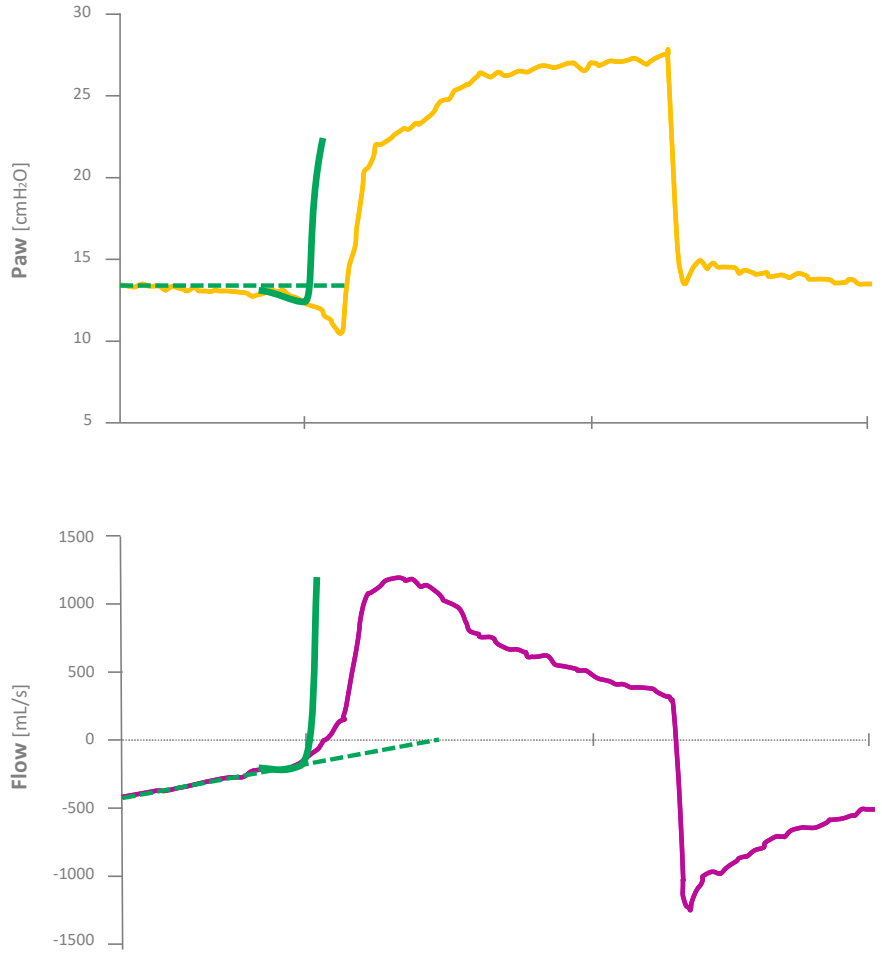


Working principle

Delayed trigger

What does it react to?

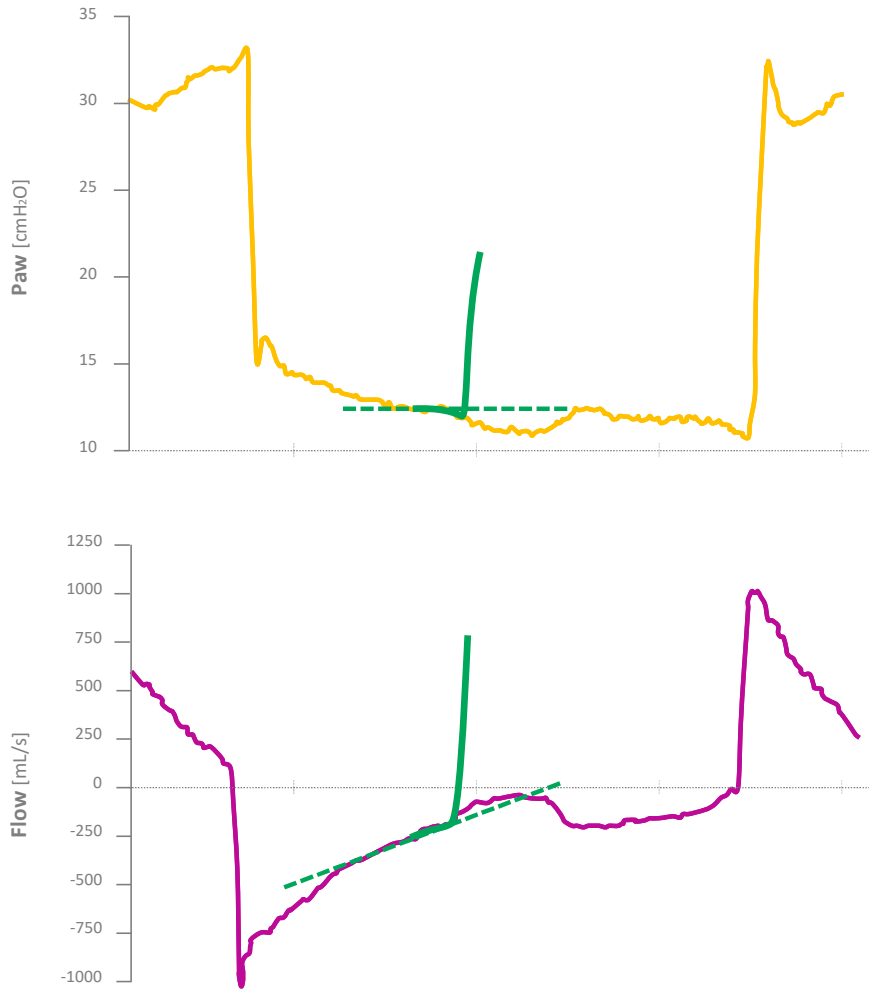
- Flow increase
- Pressure decrease



Ineffective effort

What does it react to?

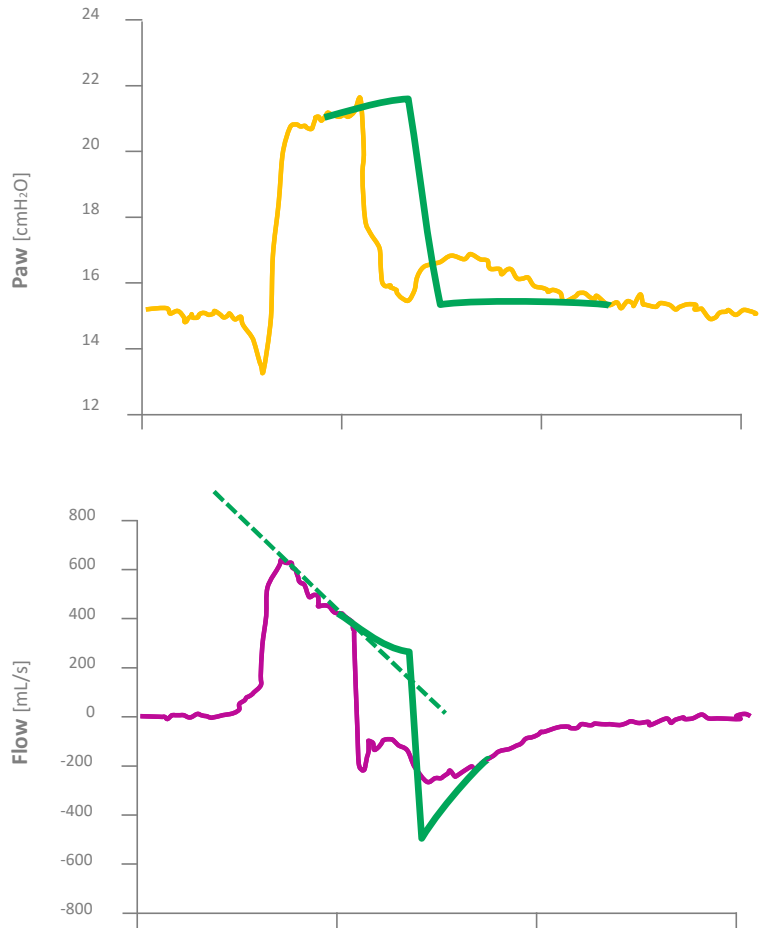
- Flow increase
- Pressure decrease



Early cycling

What does it not react to?

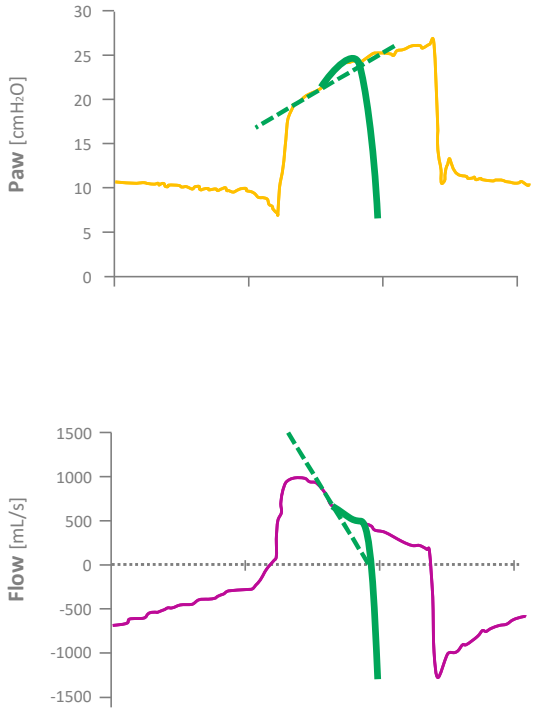
- Steady flow decrease



Late cycling

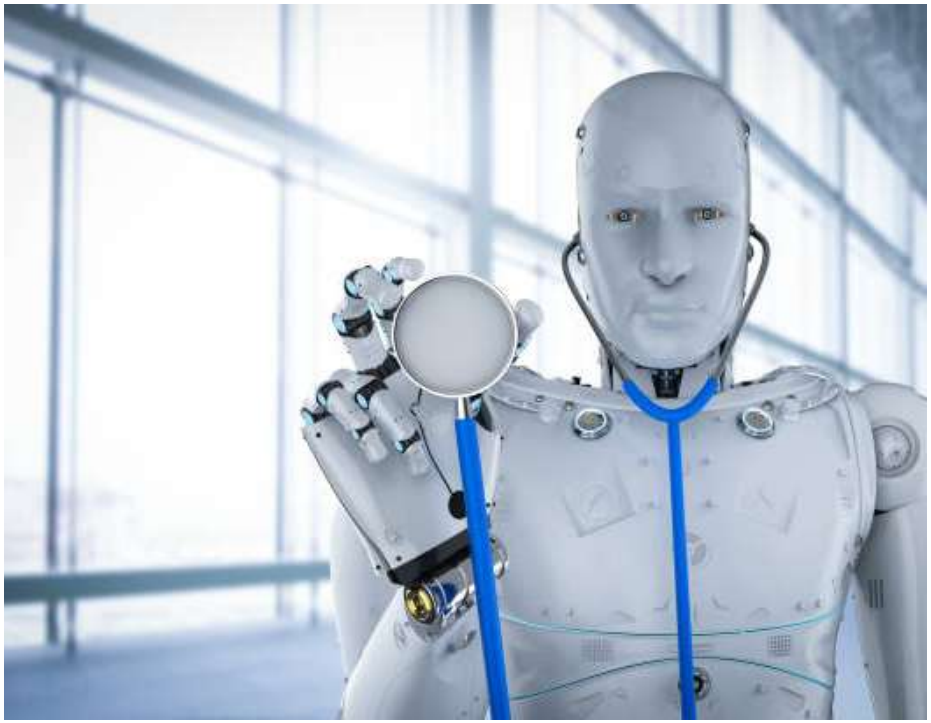
What does it react to?

- Flow deflection
- Pressure increase



* Sign of inspiratory muscle relaxation or expiratory muscle contraction

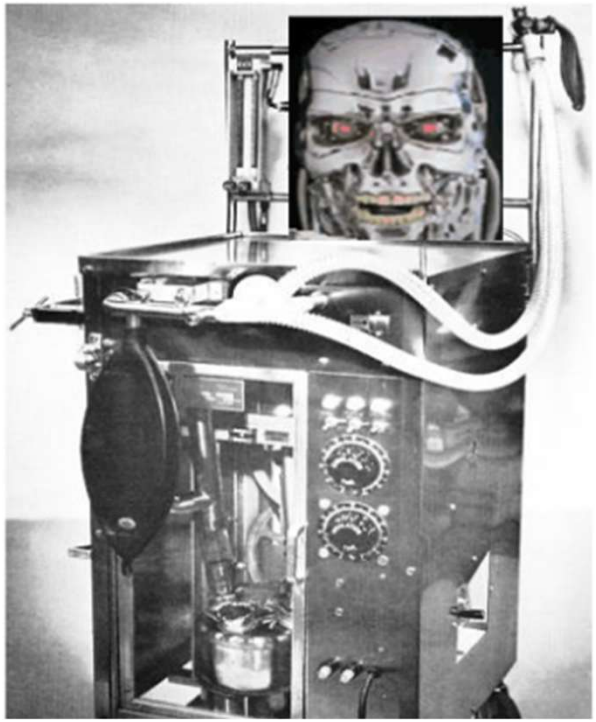
Potential for Good



- ✓ Predictive Analytics
  - ✓ Provide real time predictions of patient needs allowing for more proactive and personal treatment
- ✓ Automated decision making
  - ✓ AI will be able to make automated decisions
    - ✓ Adjusting ventilation settings

Potential for Good

- ✓ Improved patient outcomes
  - ✓ Leads improved outcomes through more precise and efficient treatment
- ✓ Cost Savings
  - ✓ Reduces the need for intervention
  - ✓ Redices the risk of harm to patient
  - ✓ Reduces VAE's
  - ✓ Decreases time on ventilator

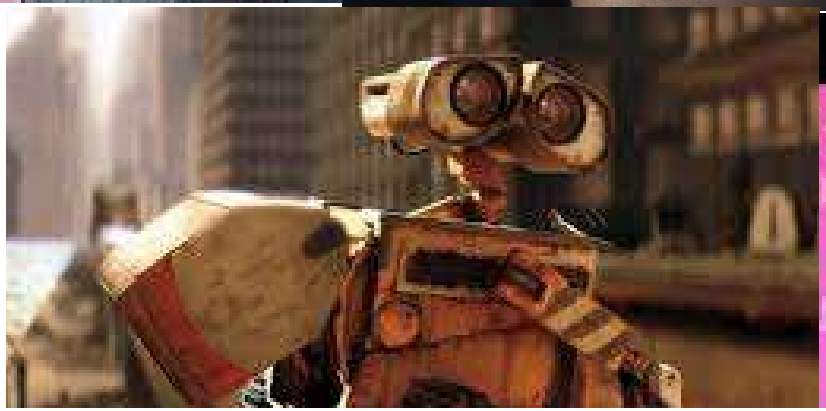


Potential for Evil

Still Hope








Thank you for your attention!!

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www.hamilton-medical.com

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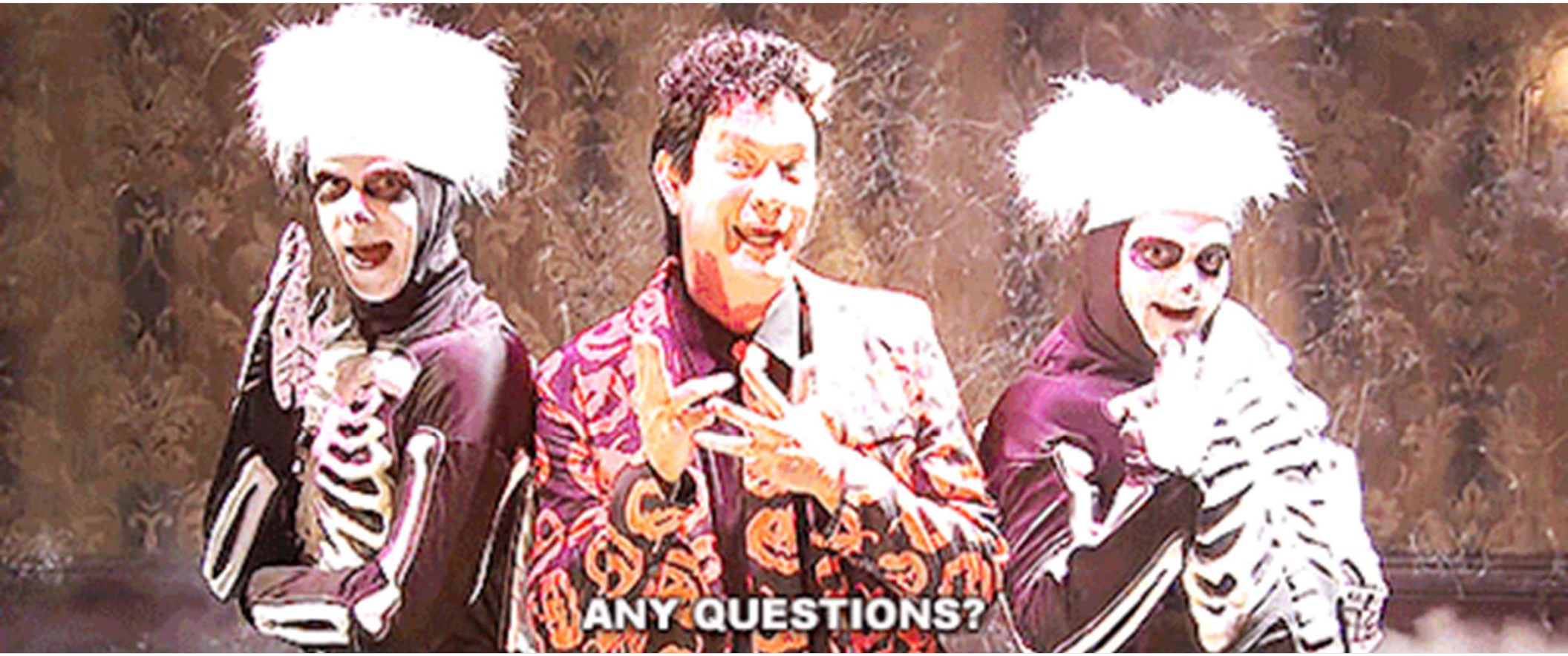
Intelligent Ventilation since 1983

Questions?



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Special layout elements

Table

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Row 1					
Row 2					
Row 3					
Row 4					
Row 5					
Row 6					

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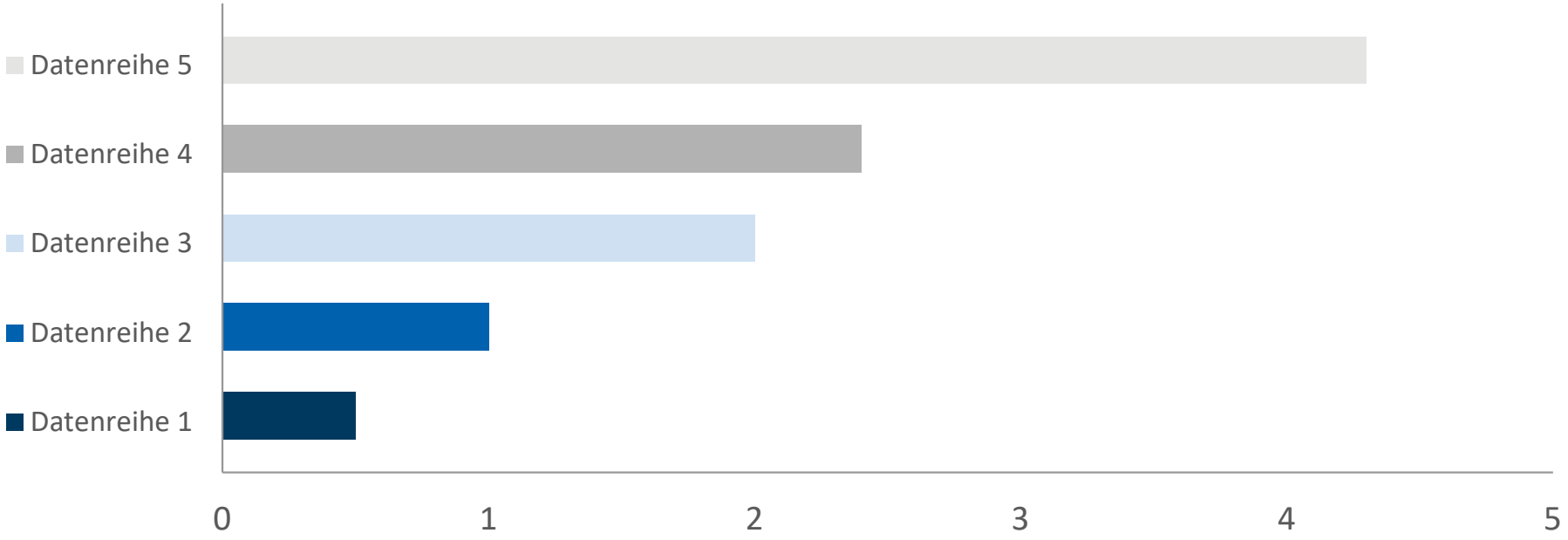
Bar chart


Datenreihe 5
Datenreihe 4
Datenreihe 3
Datenreihe 2
Datenreihe 1
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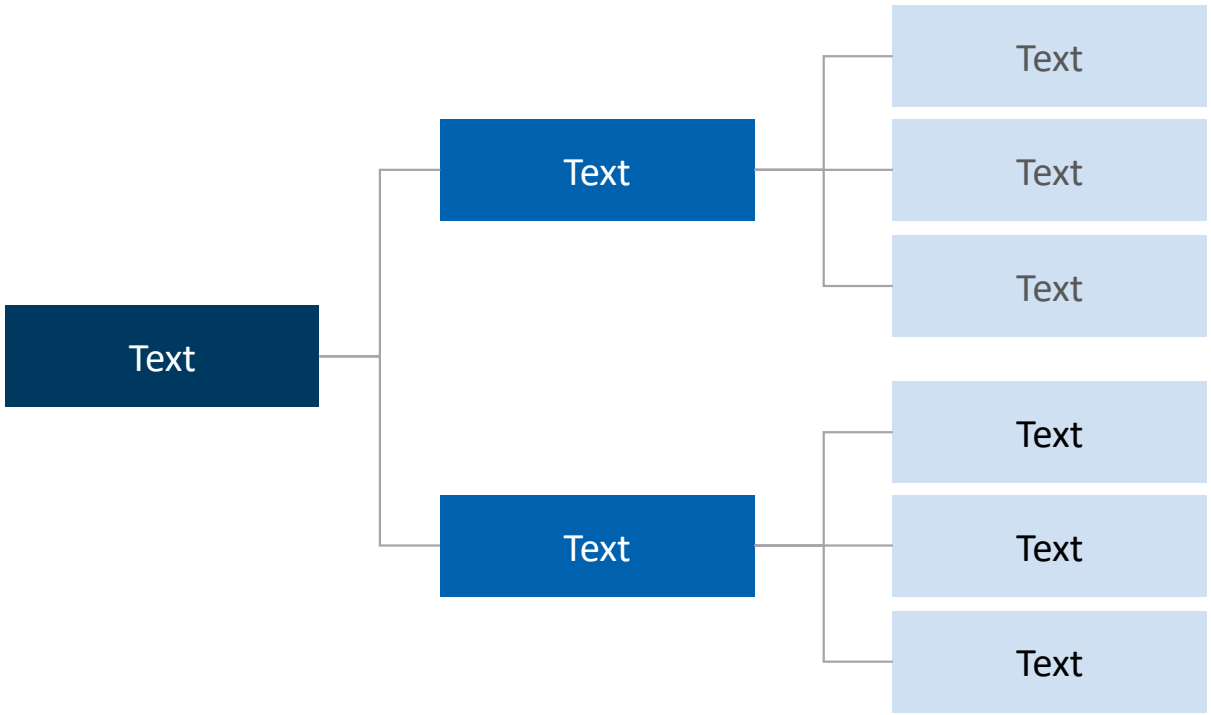
3
4
5

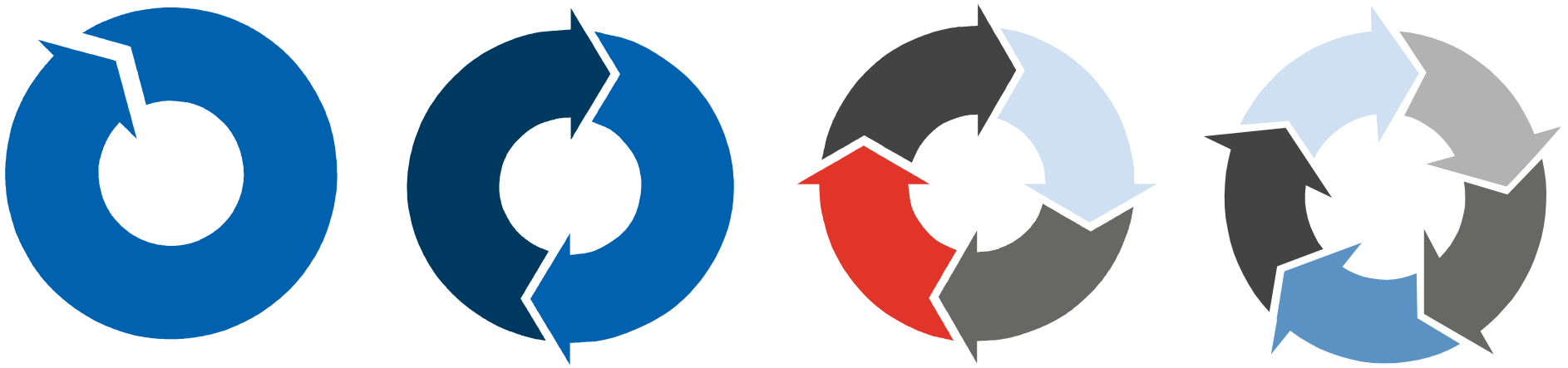
Process flow

- Text
  - Text
- Text
  - Text
- Text
  - Text
- Text
  - Text
- Text
  - Text

Trees – horizontal



Continuous circle



Thank you for your attention.

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ELO-Nr (if required)