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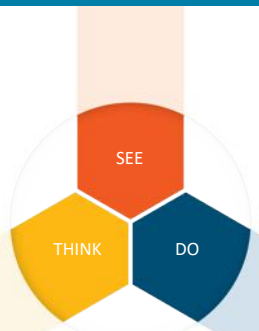


Robotics for a better tomorrow

Henrik I. Christensen
hichristensen@ucsd.edu

UC San Diego JACOBS SCHOOL OF ENGINEERING | UC San Diego SOCIAL SCIENCES

Roadmap for Robotics 2024

- Mega Trends
- Business Drivers
- Obstacles to Progress
- R&D Opportunities
- Misc

Roadmaps

Mega Trends

- Robotics as the embodiment of AI/ML
- Workforce shortage
- Digital Economy
- Changing Demographics
- Sustainability
- The world is no longer flat

Speed and scale… yesterday

Supply side economics of scale

Examples

Implications for firms

- Costs decline with higher volume of output
- Strong competitive advantages to building larger and larger production facilities

Speed and scale … today

Demand-side economies of scale

Examples

Implications for firms

- Value grows with growth of networks
- Strong competitive advantages to building out network ecosystem as quickly as possible

New Rules for strategy

Rise of platforms requires a shift in corporate strategy

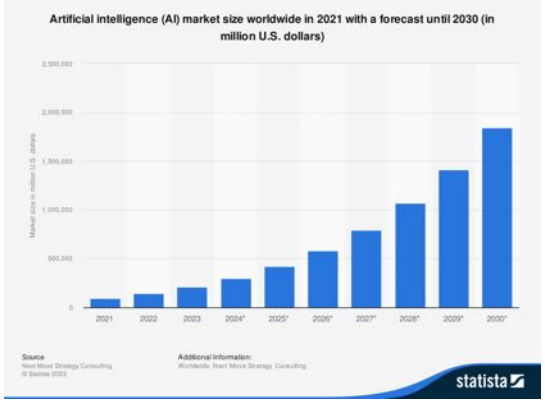
Conventional corporate strategy	*Platform strategy*
Focus on resource control	Resource orchestration
Focus on internal optimization	External interaction
Focus on product value	Ecosystem value

Source: Marshall W. Van Alstyne, Geoffrey G. Parker and Sangeet Paul Choudary, "Pipelines, Platforms, and the New Rules of Strategy, Harvard Business Review, April 2016.

Robotics embodiment of AI

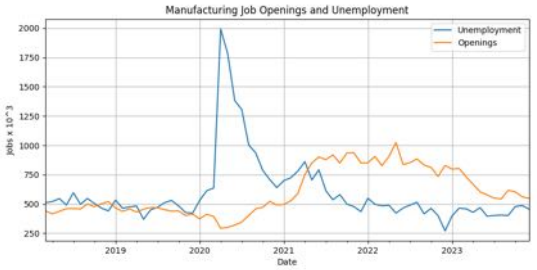
- AI is gaining momentum everywhere
  - CAGR projected to be 33% 2021-2027
  - In 2020, venture funding into AI was $40B
  - PWC predicts that 85% of companies will adopt AI within 5 years
  - 77% of everyday devices utilize some form of AI
  - WEC predicts AI will create 58 million new jobs
  - 28% annual growth in AI related patents since 2015

AI Growth



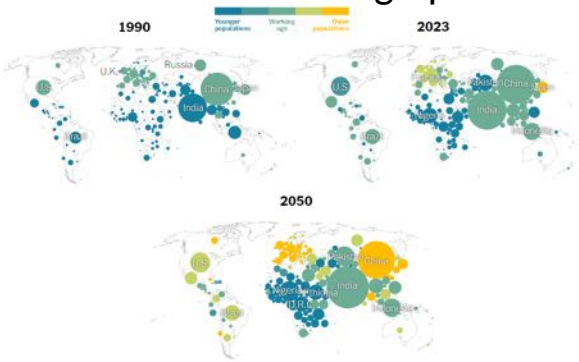
Workforce shortage

- Post covid we have seen major shortage in workforce



SRC: FRED, BLS

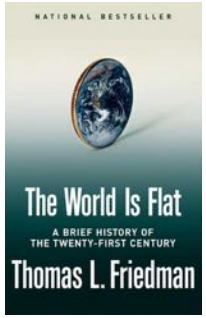
Workforce - Demographcis



SRC: NYTimes, 2023

The world is no longer flat

- Delivery time does matter
- High level of customization
- Supply chains are fragile



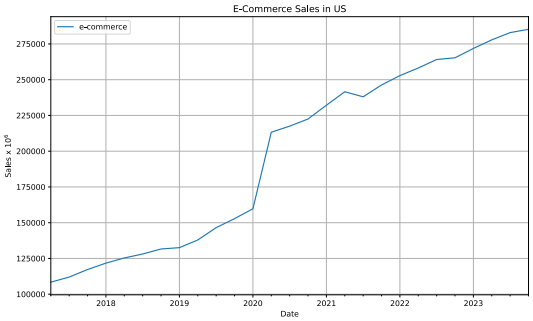
Opportunities

- Reshoring manufacturing
- The “now” economy
- Feeding the world
- Aging Society
- Housing and Infrastructure
- Sustainability
- Expanding Frontiers

Reshoring manufacturing

- Moving products closer to the customer
- Most products are unique / highly customized

E-commerce growth

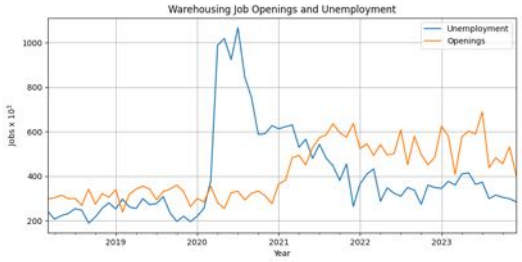


Challenges

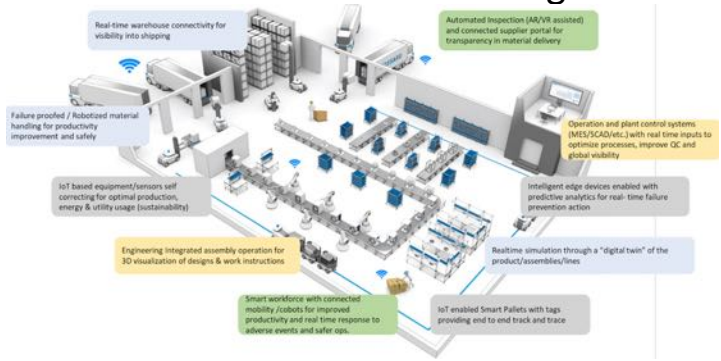
- Workforce
- Lot-Size 1 Operation
- Zero Learning Curve
- Sustainable Economy
- Privacy/Security/Trust/Safety
- Digital Production / Just in Time

Workforce

- Shortage of workforce
- Training of workforce



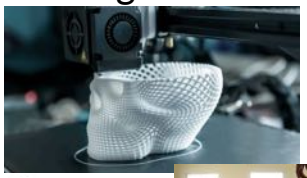
Lotsize 1 manufacturing



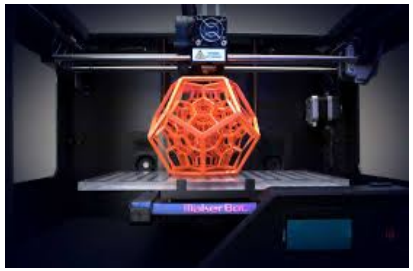
SRC: WIPRO

Zero Learning Curve

Digital Production / Just in time / manufacturing

3D printing in mixed materials

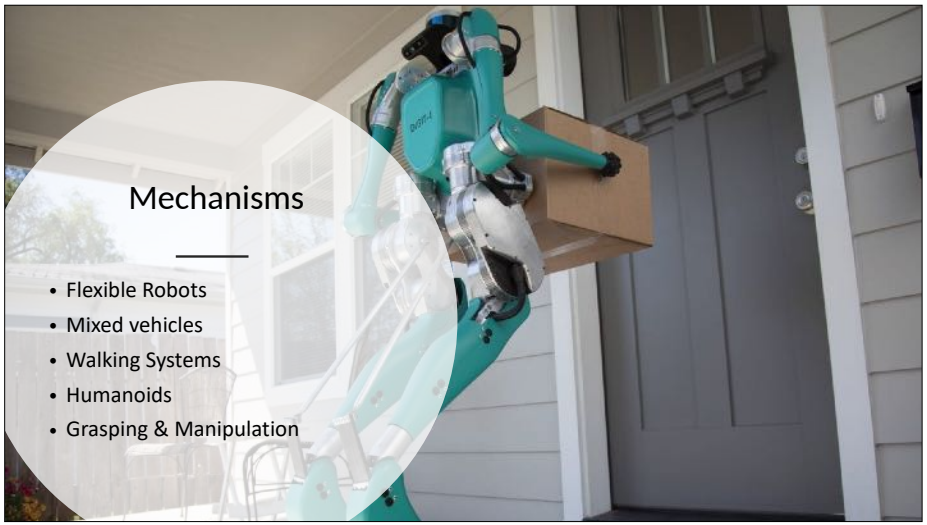


- 3D printing for spare parts
- Agile delivery
- New materials is opening markets
- Combined w. 3D scanning for repair work

- Tools for flexible additive manufacturing?

Research Opportunities

- Physical Embodiment
- Manipulation
- Perception
- Control
- Planning
- Edge AI
- Machine Learning
- Human Interaction



Mechanisms

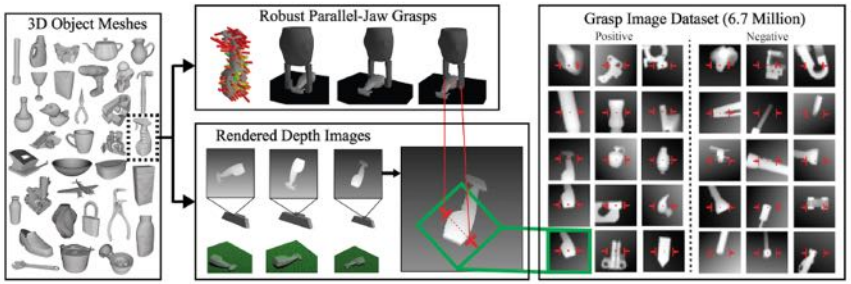
- Flexible Robots
- Mixed vehicles
- Walking Systems
- Humanoids
- Grasping & Manipulation

Grasping & Manipulation

- Beyond Models
- Scaling
- Flexibility
- Safety
- Soft Systems
- Sensorized

Collaborative Robots

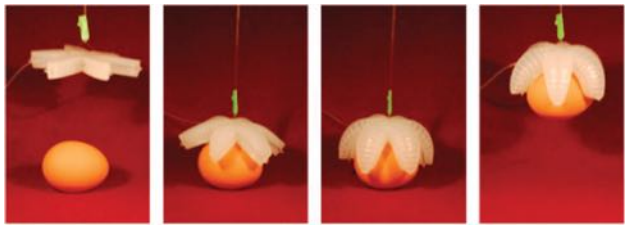
Grasping seeing real progress



Dex-Net-2.0, Mahler et al, 2017

Handling flexible objects

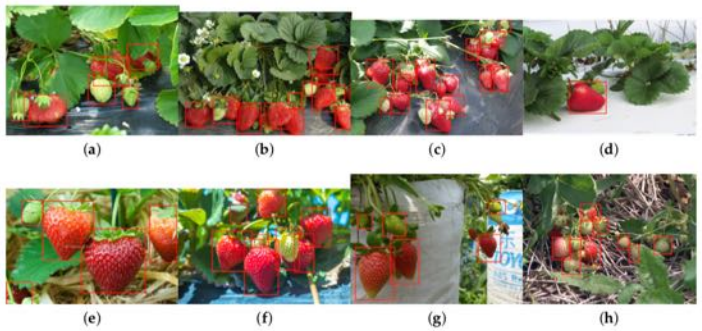
- Major progress on deformable grippers



Fast, Robust and Easy to Clean

Sensing / Perception

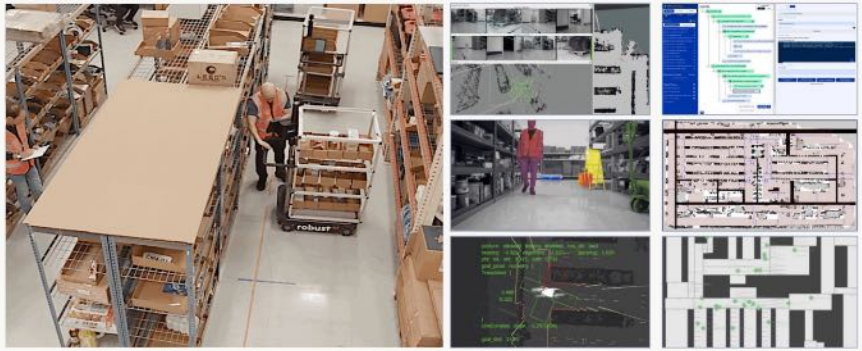
Detection of natural objects such as fruit



Src: DeepFruits

robust AI

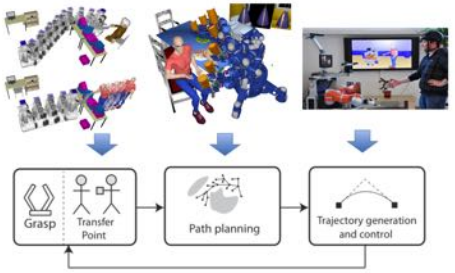
Frictionless Automation | a Breakthrough Robotics Product



Robust.AI

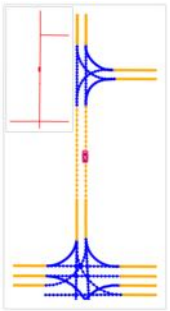
- Mapping and deployment within a week
- Fluency in human-machine cooperation (no training)
- Change in workflow to avoid (long) walks
- 30% productivity increase for DHL at 3PL sites
- Vision sensing only brings down BOM - < 10k / unit

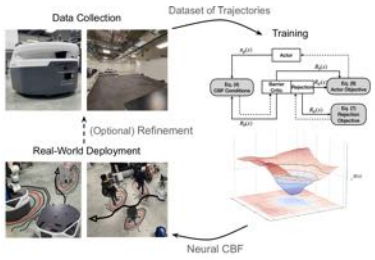
Planning and Control



Planning

- Strategic Planning
- Tactical Planning
- Execution

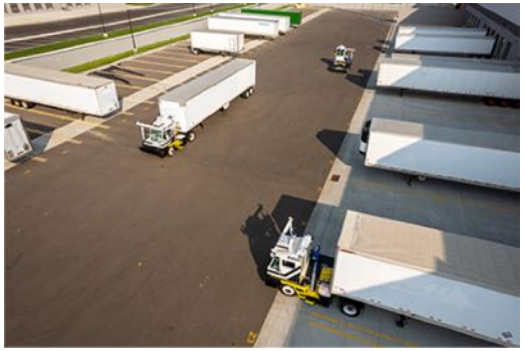




AUTONOMY

- Off- and on-road autonomy
  - Many promises but less actual deployments
- The side-effects of autonomy
  - Autonomy may not be the most important factor
  - Full efficiency, environmental impact, safety
- The challenges of autonomy
  - Certification is far from trivial

Outrider Example - Yard Automation



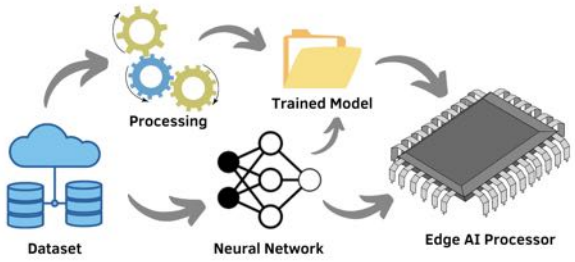
Trucks

- Aurora
- Wabi
- TuSimple
- Kodiak
- Daimler
- Scania / Volvo
- …

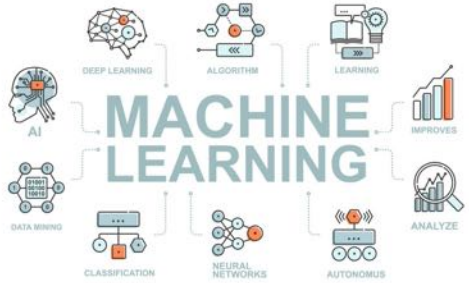
- General deployment far away
- Fuel savings is an interesting side-effect
- Yard operations likely to be first use case
- Many options for terminal operation - security, …

Amazon Scout – Certification is hard

Edge AI



Machine Learning



Next Generation Interfaces

Workforce Considerations

- Work force changes are happening
- Training will be required at all levels
- K-12 -> Trade Schools -> College
- Continuing education / Lifelong Education

- Robotics is a key enabler for STEM education

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