

# Human, Machines, and the Future of Work

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# 3 Drivers for Change

1 Advances in computing, storage, communication

2 Cost of X is Decreasing

- Computing: \$/M transistors - 33%/year
- Storage: \$/GB – 38%/year
- Bandwidth: \$/Gb/s – 27%/year
- Solar power: cents/kW.hr – 75% in 5 years
- Magnesium
- Poly Vinyl Chloride
- Fabrication

...

# 3. Speed

## 3-D Printing



MakerBot



2023

$80 \text{ cm}^3$   
 $\text{hr}^{-1}$

2018

$40 \text{ cm}^3$   
 $\text{hr}^{-1}$

2013

$10 \text{ cm}^3$   
 $\text{hr}^{-1}$

- 1 Cost of creating hardware and software is decreasing
- 2 Time to ideate, create, test and redesign is decreasing

More players...

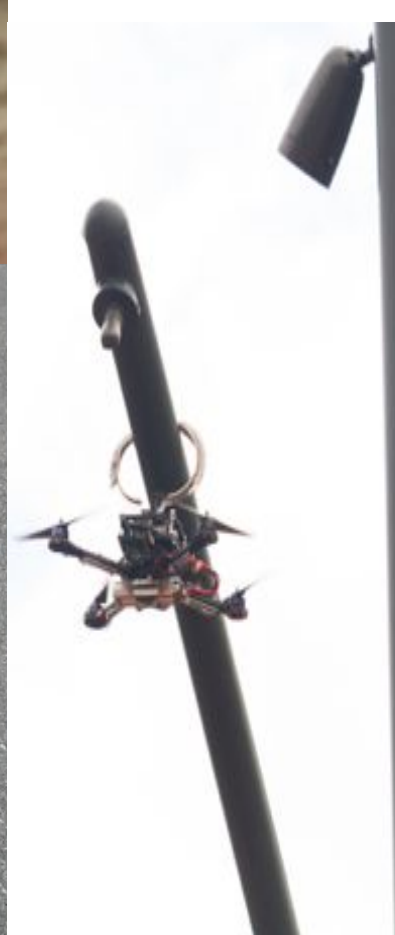
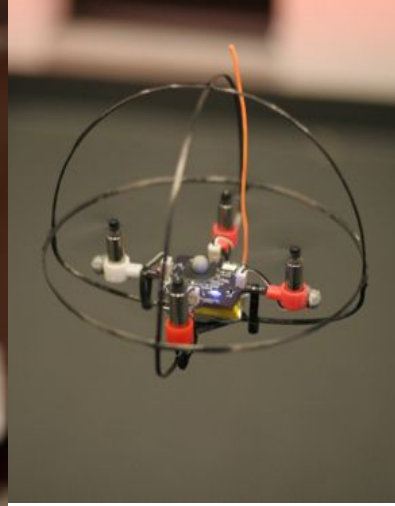
More shots on goal...

More scores...

Higher scoring game ...

Attract better talent ...

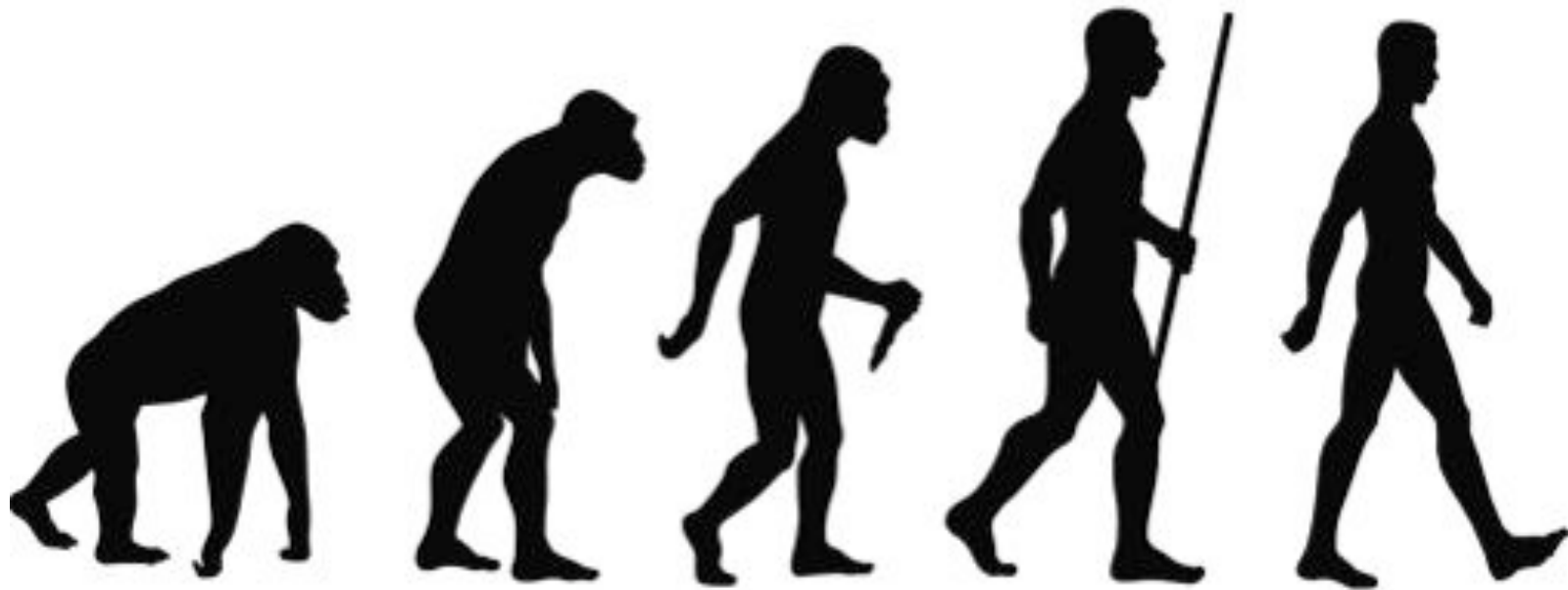
*The rate of  
technology  
innovation is  
accelerating!*



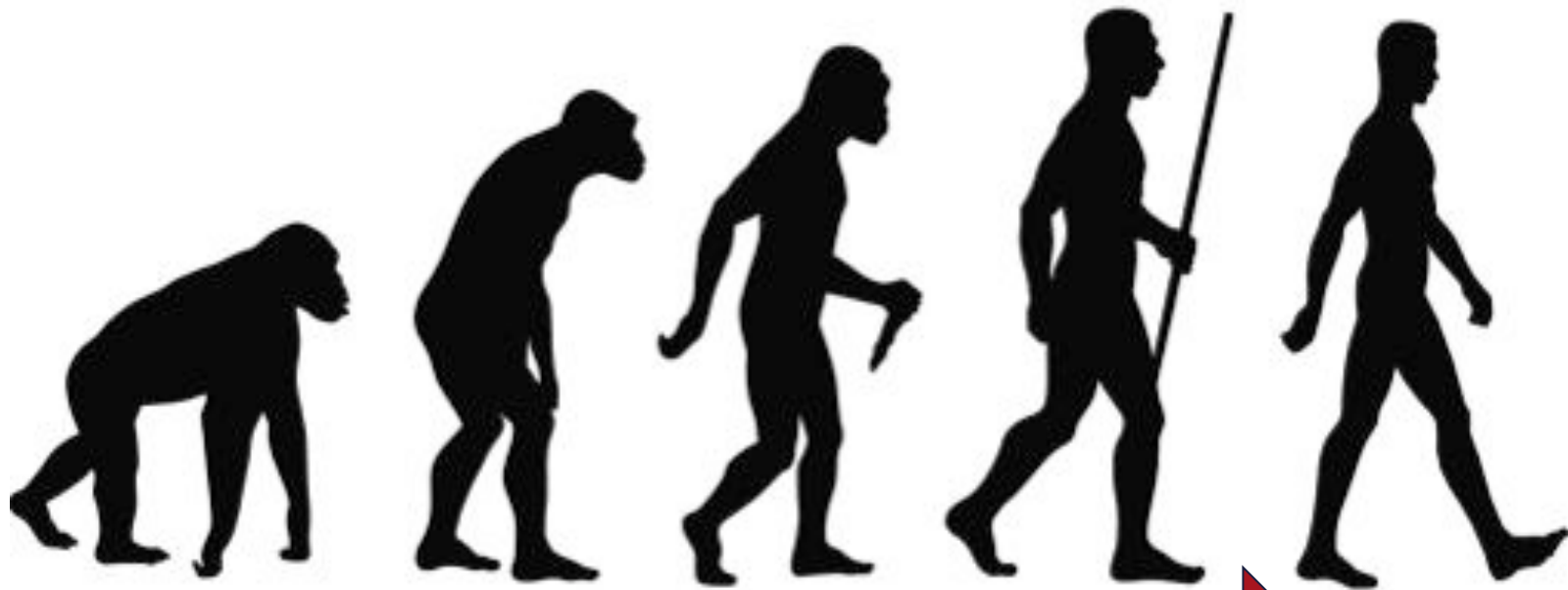
# Aerial Robotics

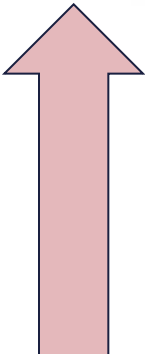
DI2016.pptx





*We are here!*



  
*We are here!*

*Small*

*Safe*

*Smart*

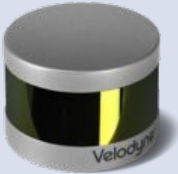
*Speed*

*Swarms*





# Light weight sensing

| Model                                                                                               | Range                           | Resolution                                           | Weight*  | Power | Cost   |
|-----------------------------------------------------------------------------------------------------|---------------------------------|------------------------------------------------------|----------|-------|--------|
| <br>HDL-64E        | 120 m.<br>26.8° vertical<br>FOV | < 2 cm.<br>0.08° (azimuth)<br>0.4° (elevation)       | 13.2 kg. | 60 W  | \$75K  |
| <br>HDL-32E        | 100 m.<br>41° vertical<br>FOV   | ±2 cm.<br>0.1° - 0.4° (azimuth)<br>1.33° (elevation) | 1 kg.    | 12W   | \$30K  |
| <br>VLP-16 (Puck) | 100 m.<br>30° vertical<br>FOV   | ±3 cm.<br>0.1° - 0.4° (azimuth)<br>2° (elevation)    | 830 g.   | 8 W   | \$7999 |
| <br>VLP-16 Lite  | 100 m.<br>30° vertical<br>FOV   | ±3 cm.<br>0.1° - 0.4° (azimuth)<br>2° (elevation)    | 590 g.   | 8 W   | \$9399 |

# Light weight computing

| Computer                 | Intel NUC<br>(i3-5010U) | Intel NUC<br>(i5-5250U) | Intel NUC<br>(i7-5557U) | Odroid XU3<br>(Exynos 5422) | Qualcomm Eagle<br>(Snapdragon 801) |
|--------------------------|-------------------------|-------------------------|-------------------------|-----------------------------|------------------------------------|
| Cores                    | 2                       | 2                       | 2                       | 4                           | 4                                  |
| Clock Speed (GHz)        | 1.7                     | 2.1                     | 3.1                     | 2                           | 2.5                                |
| MFLOPS (Single-Core)     | 1900                    | 2730                    | 3440                    | 1030                        | 1200                               |
| MFLOPS (Multi-Core)      | 4250                    | 5400                    | 7480                    | 4270                        | 4350                               |
| Mass (g)                 | 210                     | 210                     | 210                     | 38                          | 27                                 |
| MFlops / g (Single-Core) | 9.05                    | 13                      | 16.38                   | 27.11                       | 44.44                              |
| MFlops / g Multi-Core)   | 20.24                   | 25.71                   | 35.62                   | 112.37                      | 161.11                             |

## Recent advances

- Systems can learn to be autonomous
  - Data driven approaches to perception, action
- Systems can share data, learn from each other

# AI: 6 myths/challenges

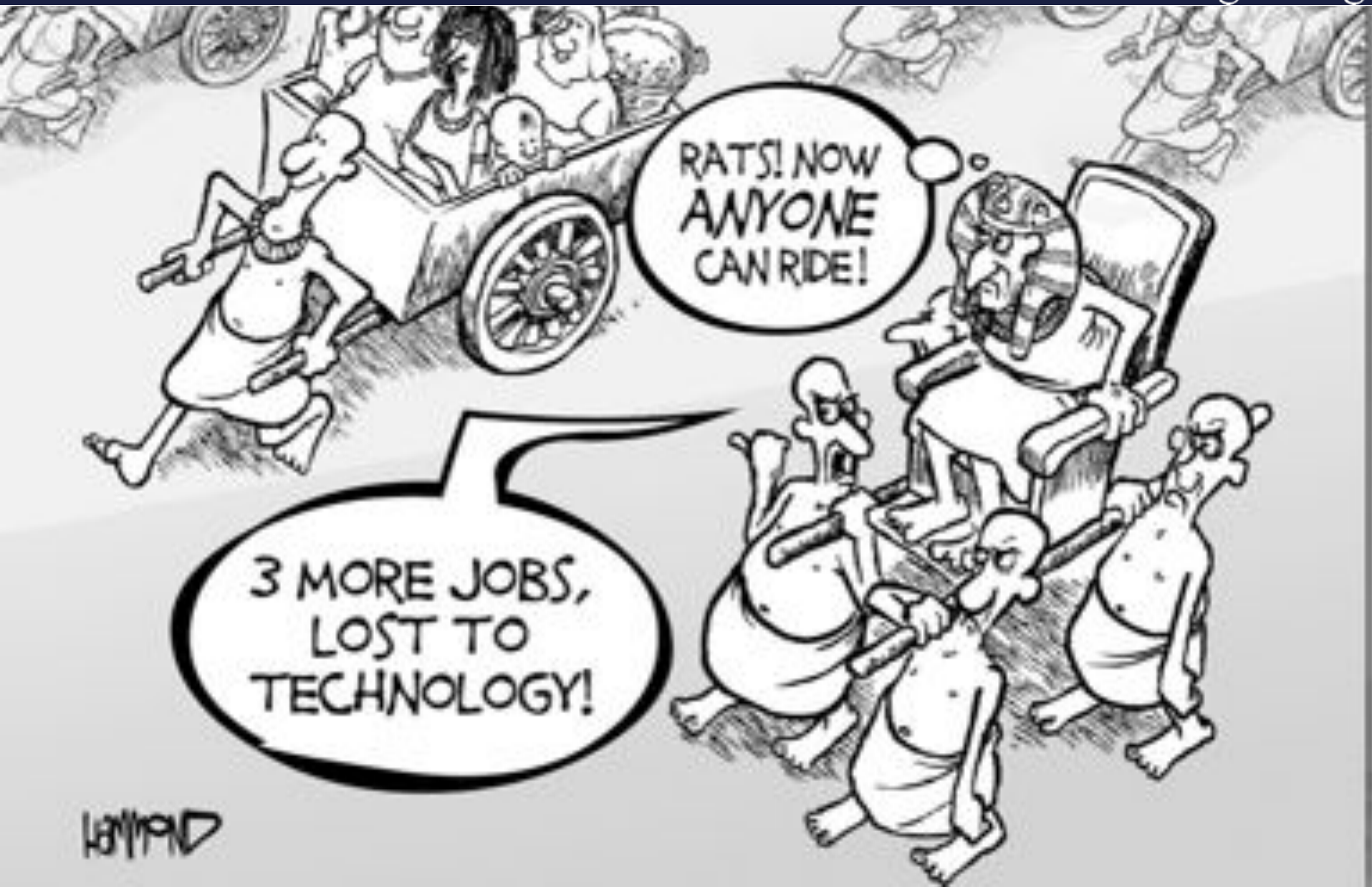
- The ability to crunch through large amounts of data (which we sometimes mistakenly call learning) does not translate to knowledge
- The ability to make complex calculations rapidly does not translate to autonomy
- 99.99% correct is exponentially harder to achieve than 90% correct
- Perception + action is exponentially harder than just perception
- Tasks with physical contact is exponentially harder than tasks like driving or flying
- Human machine collaboration is impossible unless they share representations. We only know how to do this at some very simple levels.

# AI, Autonomy and Society

## Democratization of S&T (opportunity and threat)



# Democratization of Technology



Democratization of S&T (opportunity and threat)

Jobs

# Social Disruption

## 2016

| Type of Job                                  | Qualification                                                 | Wages    |
|----------------------------------------------|---------------------------------------------------------------|----------|
| Highly skilled, analytical, making decisions | Advanced degree, tech skills balanced with emotional judgment | \$\$\$\$ |
| Analytical, drawing inferences               | College degree                                                | \$\$\$   |
| Modest skills, some labor                    | High school education                                         | \$\$     |
| Unskilled labor                              | reading/writing                                               | \$       |

# Social Disruption

## 2020

| Type of Job                                  | Qualification                                                 | Wages    |
|----------------------------------------------|---------------------------------------------------------------|----------|
| Highly skilled, analytical, making decisions | Advanced degree, tech skills balanced with emotional judgment | \$\$\$\$ |
| Analytical, drawing inferences               | College degree                                                | \$\$\$   |
| Modest skills, some labor                    | High school education                                         | \$\$     |
| Unskilled labor                              | Manual skills                                                 | \$       |



Democratization of S&T (opportunity and threat)

Jobs

Asymmetric threats (easy to write “bad” programs)

Safety

Cyber physical systems security

Privacy

Autonomy in Cyber Physical systems (as we imagine) will be difficult to achieve

Time scale of technology change (years) is much shorter than time scale of a human (decades)

Our role

- Safety
- Security
- Privacy
- Education/training