Intelligent Robotics
F20RO and F21RO

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Some definitions

- Joseph Engelberger, founder of Unimation Inc (in 1956)
  - "I can't define a robot, but I know one when I see one."
- Wikipedia (oblig.) taken from OED (Nov 2016)
  - "A robot is a **machine** - especially one **programmable by a computer** - capable of carrying out a **complex series of actions automatically**."
- ISO 8373 definition of an "**industrial robot**"
  - "An **automatically controlled, reprogrammable, multipurpose, manipulator programmable in three or more axes**, which may be **either fixed in place or mobile** for use in **industrial automation** applications."
- Suggested definition of a "**service robot**" from the International Federation of Robotics
  - "A service robot is a **robot** which operates **semi- or fully autonomously** to perform services **useful to the well-being of humans and equipment**, **excluding manufacturing** operations."

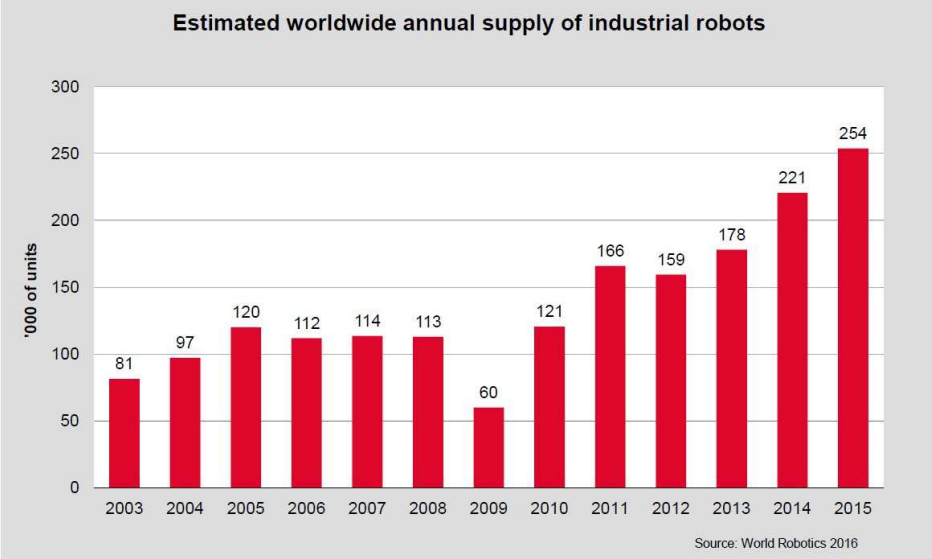
A Taxonomy of Robot Systems

- Operating Environment
  - Land, Sea(surface), Sea(subsea), Air, Space
- Mobility
  - Fixed, Tracked, Wheeled, Legged, Marine, Submarine, Aerial
- Anatomy
  - Fixed, Reconfigurable
- Control
  - Tele-operation, Programming Interface, Autonomous Behaviour, Human-Robot Interaction
- Sensors
  - None, Tactile, Force, Sonar, Audio, Infrared, Imaging, Video
- Cognition
  - Dumb, Recognition, Planning, Learning, Adaptation

A Taxonomy of Robot Domains

- Industry
  - Manipulators with assorted end effectors, Specialist assembly robots, Transportation devices
- Offshore
  - Remotely Operated Vehicles, Autonomous Underwater Vehicles (AUVs), Surface vessels
- Transport
  - Warehousing carts, Driverless vehicles, Unmanned Aerial Vehicles (UAVs), Planetary rovers
- Healthcare
  - High precision surgical devices, Social care robots, Nanobots?
- Military
  - Drones (remotely piloted), Lethal Autonomous Weapons Systems (LAWS)

Industrial robot sales

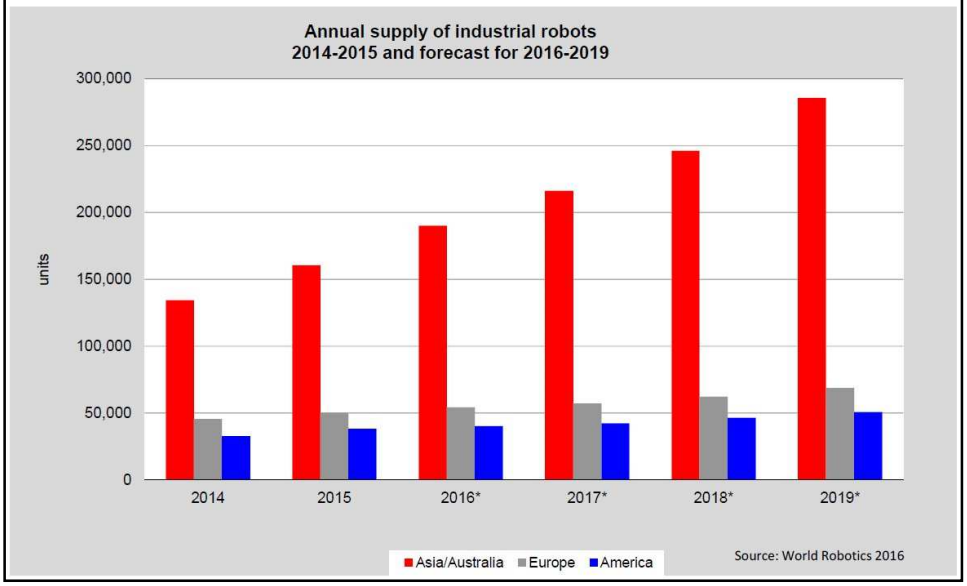


How many are there?

- The **total worldwide stock** of operational industrial robots at the **end of 2015** was approximately **1.6 million units**
- **Since 2010** the stock has been **increasing by 9% per year on average** (but note sales dip in 2009)
- **In 2015** the **sales value** reached a new peak of **$11.1 billion**
- The worldwide market value for **robot systems in 2015** was estimated to be **$35 billion**

- Source: World Robotics 2016

Where are they?



Where are they?

Country	2014	2015	2016*	2019*
America	**32,616**	**38,134**	**40,200**	**50,700**
Brazil	1,266	1,407	1,800	3,500
North America	31,029	36,444	38,000	46,000
Rest of South America	321	283	400	1,200
Asia/Australia	**134,444**	**160,558**	**190,200**	**285,700**
China	57,096	68,556	90,000	160,000
India	2,126	2,065	2,600	6,000
Japan	29,297	35,023	38,000	43,000
Republic of Korea	24,721	38,285	40,000	46,000
Taiwan	6,912	7,200	9,000	13,000
Thailand	3,657	2,556	3,000	4,500
other Asia/Australia	10,635	6,873	7,600	13,200
Europe	**45,559**	**50,073**	**54,200**	**68,800**
Central/Eastern Europe	4,643	5,976	7,550	11,300
France	2,944	3,045	3,300	4,500
Germany	20,051	20,105	21,000	25,000
Italy	6,215	6,657	7,200	9,000
Spain	2,312	3,766	4,100	5,100
United Kingdom	2,094	1,645	1,800	2,500
other Europe	7,300	8,879	9,250	11,400
Africa	**428**	**348**	**400**	**800**
not specified by countries**	7,524	4,635	5,000	8,000
Total	**220,571**	**253,748**	**290,000**	**414,000**

Sources: IFR, national robot associations.

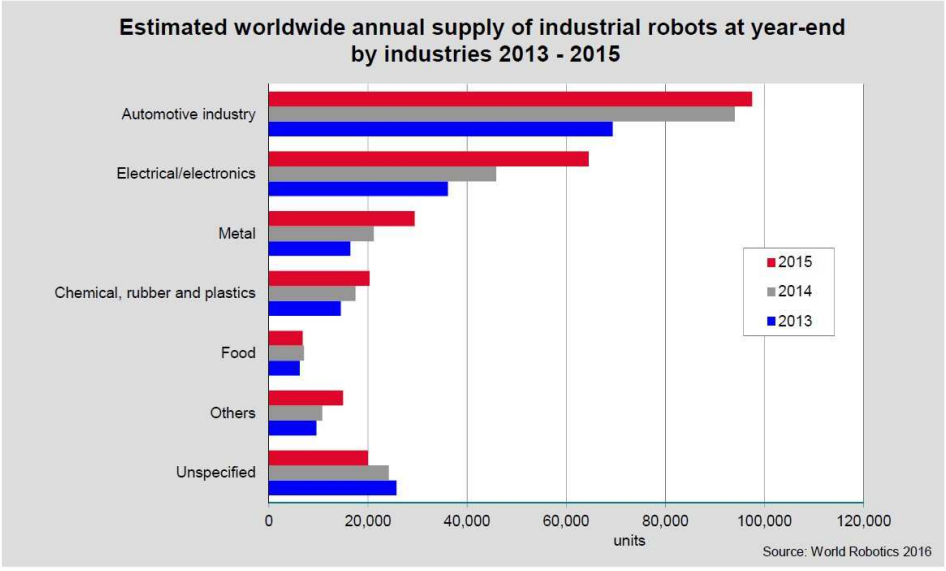
*forecast

** reported and estimated sales which could not be specified by countries

Where are they?

- The average global **robot density** was about 69 industrial robots installed per 10,000 employees in manufacturing industry in 2015
- This density rises to over 1,000 in the automotive industry
- The Republic of Korea has by far the highest robot density in manufacturing as a whole but Japan has the highest in the automotive industry
- Top 5 countries by robot density in 2015
  - South Korea, Singapore, Japan, Germany, USA

What are they doing?



Intelligent Robotics Plan 2018-2019

Katrin Lohan (KL), Nick Taylor (NT)

Week	Mondays/Lecture (EM1.83) 11:15-12:15	Mondays/Lab (EM2.50) 15:15-16:15	Tuesdays/Lecture (EM1.83) 09:15-10:15	Thursdays/Tutorial (WA1.11) 11:15-12:15
1. 10/09	L1 Introduction NT	NO Class	L2 NT	Lab visit
2. 17/09	L3 NT	Assignment 1 Induction	L4 NT	Tutorial 1 NT
3. 24/09	L5 NT		L6 NT	Tutorial 2 NT
4. 01/10	L7 NT		L8 NT	Tutorial 3 NT
5. 08/10	L9 NT		L10 NT	Tutorial 4 NT
6. 15/10	L11 NT	Assignment 1 Demos and submission	L12 NT	NO CLASS
7. 22/10	L13 KL	LAB 1 Assignment 2 Introduction	L14 KL	NO CLASS
8. 29/10	L15 KL	LAB 2	L16 KL	NO CLASS
9. 05/11	L17 KL	LAB 3	L18 KL	NO CLASS
10. 12/11	L19 KL	LAB 4 Assignment 2: Demo Marking	L20 KL	NO CLASS
11. 19/11	L21 KL	NO CLASS	L22 KL	NO CLASS
12. 26/11	Revision KL		Revision KL	

Coverage

- Nick
  - Industrial Robotics
    - Manipulator Kinematics, Inverse Kinematics, Velocity and Path Control
    - AGV Navigation and Mapping
  - Swarm Robotics
    - Swarm Intelligence and Optimisation Algorithms (PSO, ACO)
    - Physical Swarms and Biological Inspiration
- Katrin
  - Cognitive Robotics
    - Developmental Robotics
    - Human-Robot Interaction
    - Embodiment
  - Adaptation, Learning and Evolution
    - Behaviour Based Robotics
    - Evolutionary Robotics

Assessment

- 2 Assignments (each 20%) throughout course
  - Lab-based using Java 3D program and iCub simulator
  - Demo plus hand-in Assignment 1 week 6
  - Demo plus hand-in Assignment 2 week 10
- Examination (60%)
  - Answer 3 questions from 4

Labs

- Start in Week 2
- Mondays 15:15-16:15
- Linux Lab (Room EM2.50)
- Robotics Lab visits Thursday in Week 1
  - Meet in the Earl Mountbatten Building "Learning Zone" (aka Crush Area) at 11:15am

Any Questions?