Intelligent Machines & Systems

Perspectives for the course
(Introductory Session 2015)

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Different scenarios

- Manufacturing (in Industry) for Engineers
  - Why is “Intelligent Systems” relevant here?
- Robotics
- Autonomous Systems
- Other Applications
- Types of Intelligent Systems applications
- Current Trends

Developments in Manufacturing Automation

STAGE	FEATURE	AUTOMATION	DESIGN	MANUFACTURE
1	Labour Intensive	None	Individual	Manual
2	Equipment-intensive	Instruments	Group	NC,CNC
3	Information-Intensive	Information	CAD	FMS
4	Knowledge-Intensive	Decision	ICAD	CIMS

Problems in Industry

- Too much information needs manipulation
- Highly computerized human-machine system needs a good quality interaction between operator and the system.
- Involvement of different sections-- conflicts /conflict resolution and reasoning strategies
- Large amount of data: How to process? How to export effectively knowledge?

Types of Intelligent Manufacturing Systems

TYPE	FEATURES
TYPE I	Symbolic Reasoning System
TYPE II	Compiling Intelligent Systems that links numerical computation programs with a symbolic reasoning system
TYPE III	Artificial Neural Networks that model the human brain and deal with empirical data
TYPE IV	Integrated distributed Intelligent Systems involving expert systems, numerical programs, neural nets and computer graphics packages

Case of an Enterprise

Hierarchical levels in Manufacturing

There are 3 basic levels of control

- Organization level
- Co-ordination level
- Execution level

Organization level

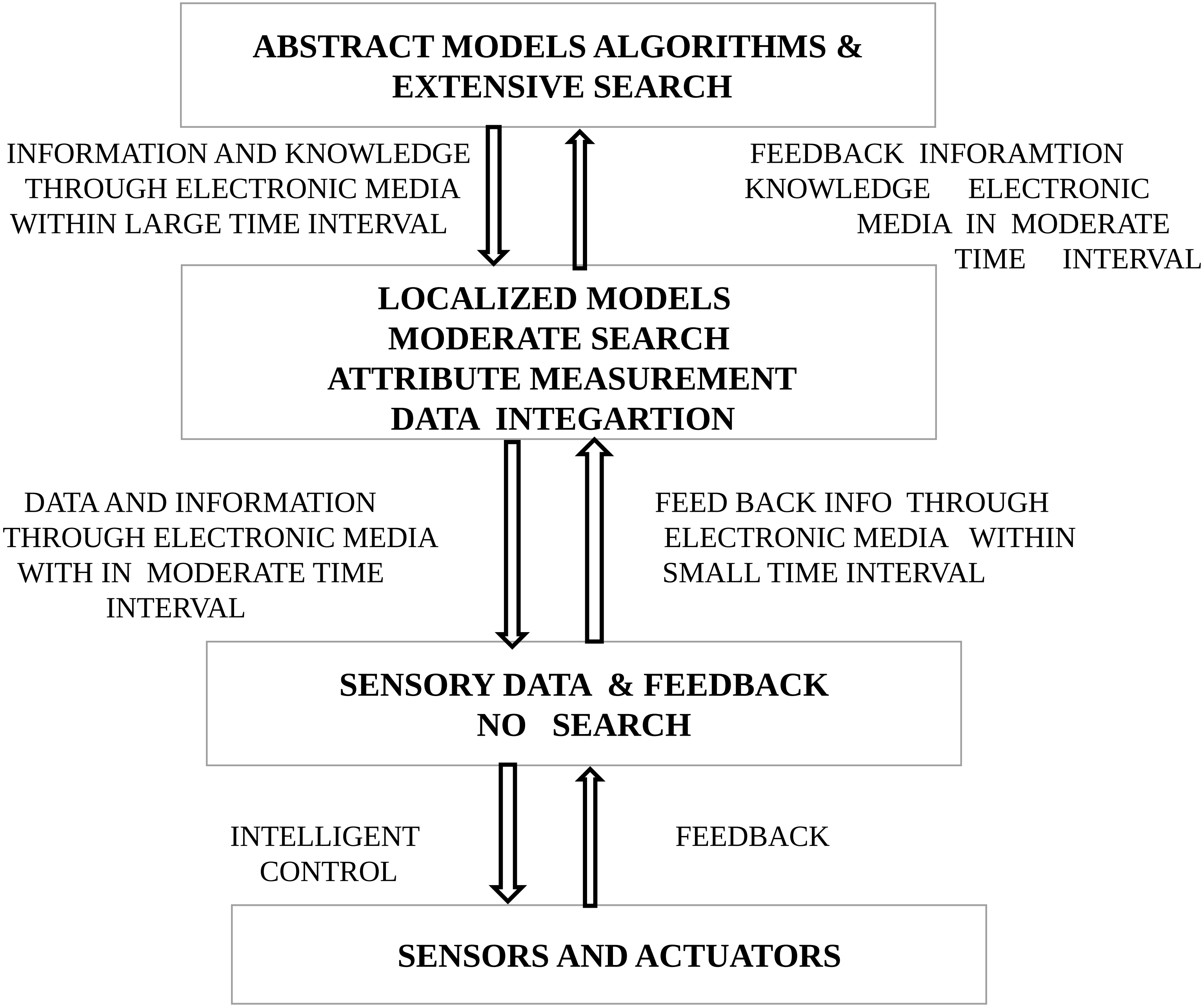
1. Product design
2. Process planning
3. Master production scheduling
4. Forecasting
5. Strategic business planning

Coordination Level

- Making short -term decisions based on inputs provided by organization level
- Detailed scheduling
- Assembly operations
- Work and purchase order generations form.

Execution Level

1. Appropriate control functions and detail feed back from actual operations of manufacturing units
2. Provides supply of info to the coordination level for possible revisions of short-term decisions and also satisfactory
3. Database for knowledge and long term strategies process monitoring and control
4. Adaptive control
5. Manufacturing system diagnostic


ABSTRACT MODELS ALGORITHMS & EXTENSIVE SEARCH
INFORMATION AND KNOWLEDGE THROUGH ELECTRONIC MEDIA WITHIN LARGE TIME INTERVAL
FEEDBACK INFORAMTION KNOWLEDGE ELECTRONIC MEDIA IN MODERATE TIME INTERVAL
LOCALIZED MODELS
MODERATE SEARCH
ATTRIBUTE MEASUREMENT
DATA INTEGARTION
DATA AND INFORMATION THROUGH ELECTRONIC MEDIA WITH IN MODERATE TIME INTERVAL
FEED BACK INFO THROUGH ELECTRONIC MEDIA WITHIN SMALL TIME INTERVAL
SENSORY DATA & FEEDBACK
NO SEARCH
INTELLIGENT CONTROL
FEEDBACK
SENSORS AND ACTUATORS

Summary of requirements

ORGANISATION LEVEL	EXTENSIVE SEARCH LOW PRECISION	ABSTRACT MODEL ALGORITHM
COORDINATION LEVEL	MODERATE SEARCH MODERATE PRECISION	LOCALIZED MODELS ATTRIBUTE MEASUREMENT DATA INTEGRATION
EXECUTION LEVEL	NO SEARCH HIGH PRECISION	SENSORY DATA FEEDBACK SMALL TIME IMCREMENTS

What is Intelligence?

“The ability of the system to act appropriately in an uncertain environment, where appropriate action is that which increases the probability of success, and success is the achievement of behaviors sub-goals that support the systems ultimate goal"

Criteria of success and ultimate goal defined external to the Intelligent System.

J. Albus, “Outline for a Theory of Intelligence,” IEEE Transactions on Systems, Man, and Cybernetics, Vol. 21, No. 3, May/June, 1991, pp. 473-509

3 Degrees of Intelligence

- COMPUTATION POWER
- COMPLEXITY OF THE ALGORITHMS USED BY THE SYSTEM PROCESSING INPUT AND SOPHISTICATION OF SYSTEM ELEMENTS
- THE INFORMATION AND VALUES STORED INSYSTEM MEMORY

4 Elements of Intelligent Systems

- SENSORY PROCESSING
- WORK MODEL
- VALUE JUDGEMENT
- BEHAVIOUR GENERATION

Generations of Intelligent Systems

- Artificial Intelligence (AI) based systems
- Connectionist and Machine Learning
- Agent Based Systems
- Evolutionary Systems
- Cognitive Systems, Cybernetic and Cyber Physical Systems

AI based Systems

- Expert Systems
- Rule based
- Knowledge expert
- Very rigid formulations
- Fragile to unknown situations

Connectionist & Machine Learning

- Neural Network based
  - Biological neurons analogy
  - Different learning theories
- Fuzzy Logic based
  - Distributed memory based
  - Rule based
- Redundancy and Robustness

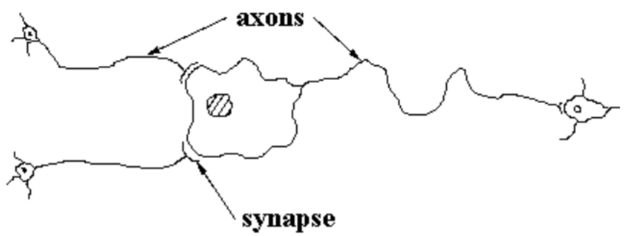
Agent based Systems

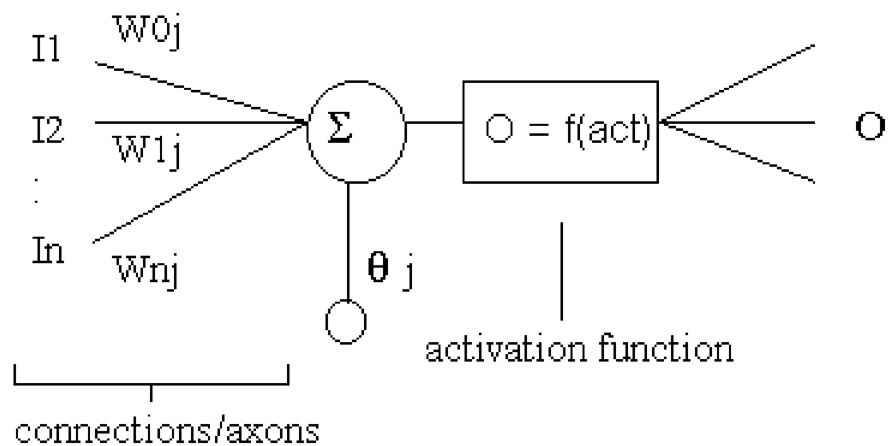
- Distributed intelligence
- Specialist knowledge
- Interaction between subsystems
- Complex Behaviors
- Subsumption architecture
- Intelligent Robotics

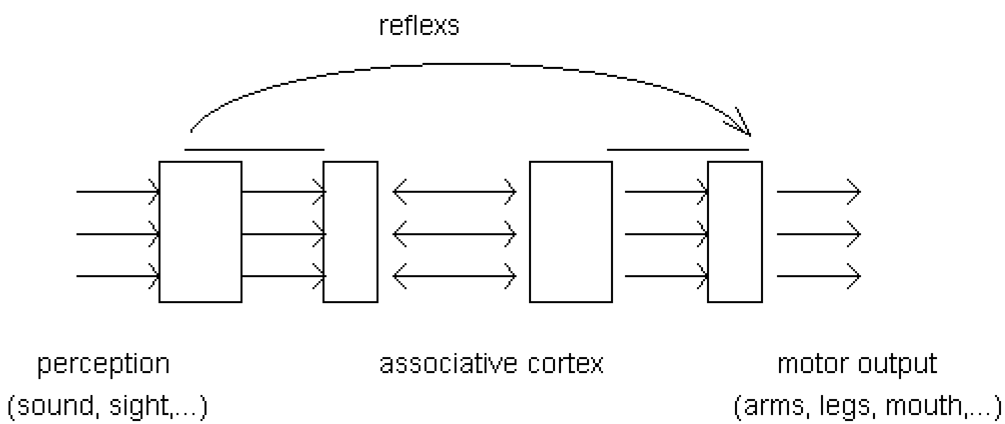
Evolutionary Intelligent Systems

- Genetic Algorithms
- Based on natural evolution theories
- Adaptability
- Evolution and optimization
- Complex learning behaviors
- Emergent behaviours

Neural network based intelligence







- Connectionist Approach
- Machine Learning
- Cognitive Sciences
- Cognitive Architectures
- (Bio)Neuro-Cybernetics

- Cognitive Computing
- Computational Models for Cognition

Intelligent Robotics

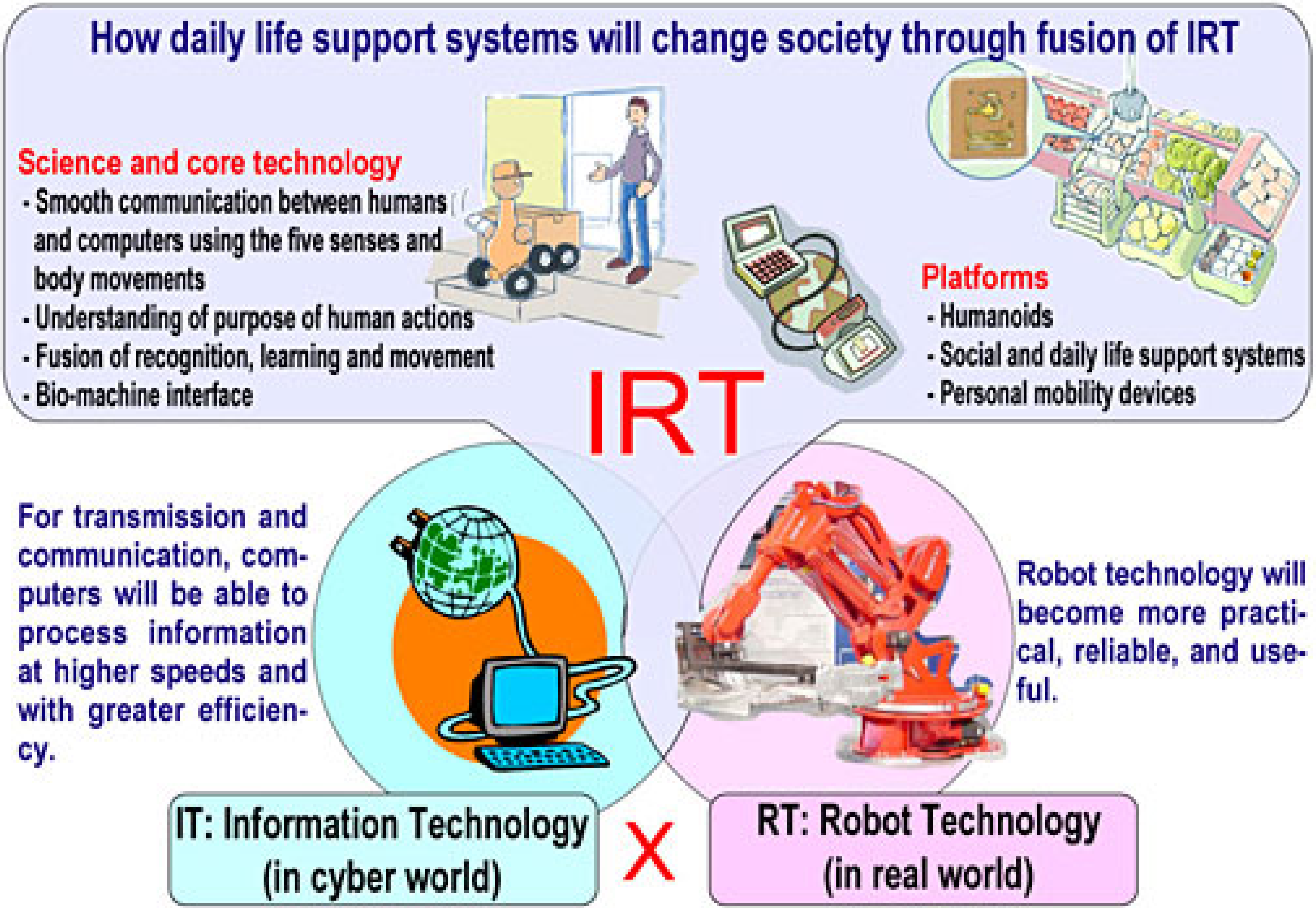
- Platform for developing and evolving Intelligent systems
- Lab and large scale versions available
- Ease of deployment as test beds
- Competition versions popular in students

Different Directions of IS in Robotics

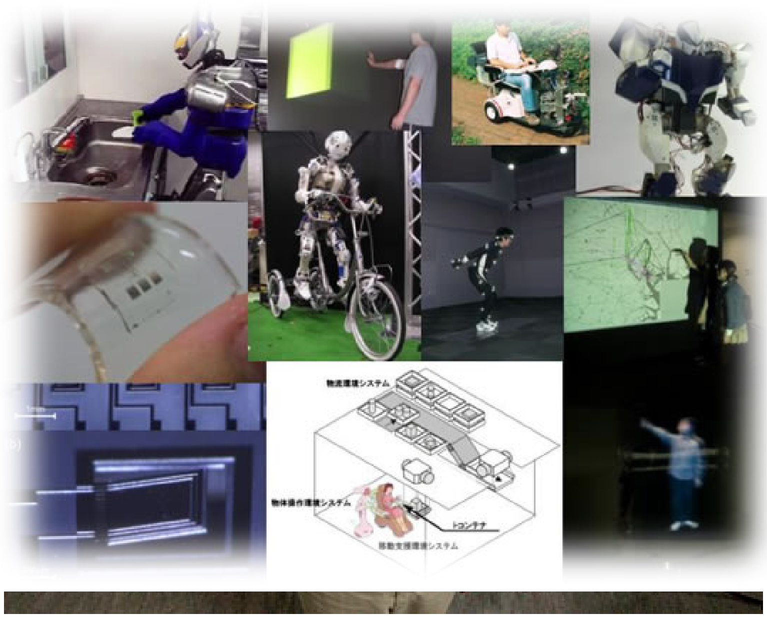
- Service and Assistive Robotics
- Autonomous Robots
- Rehabilitation
- Cognitive Robotics
- Swarm Robotics

Components

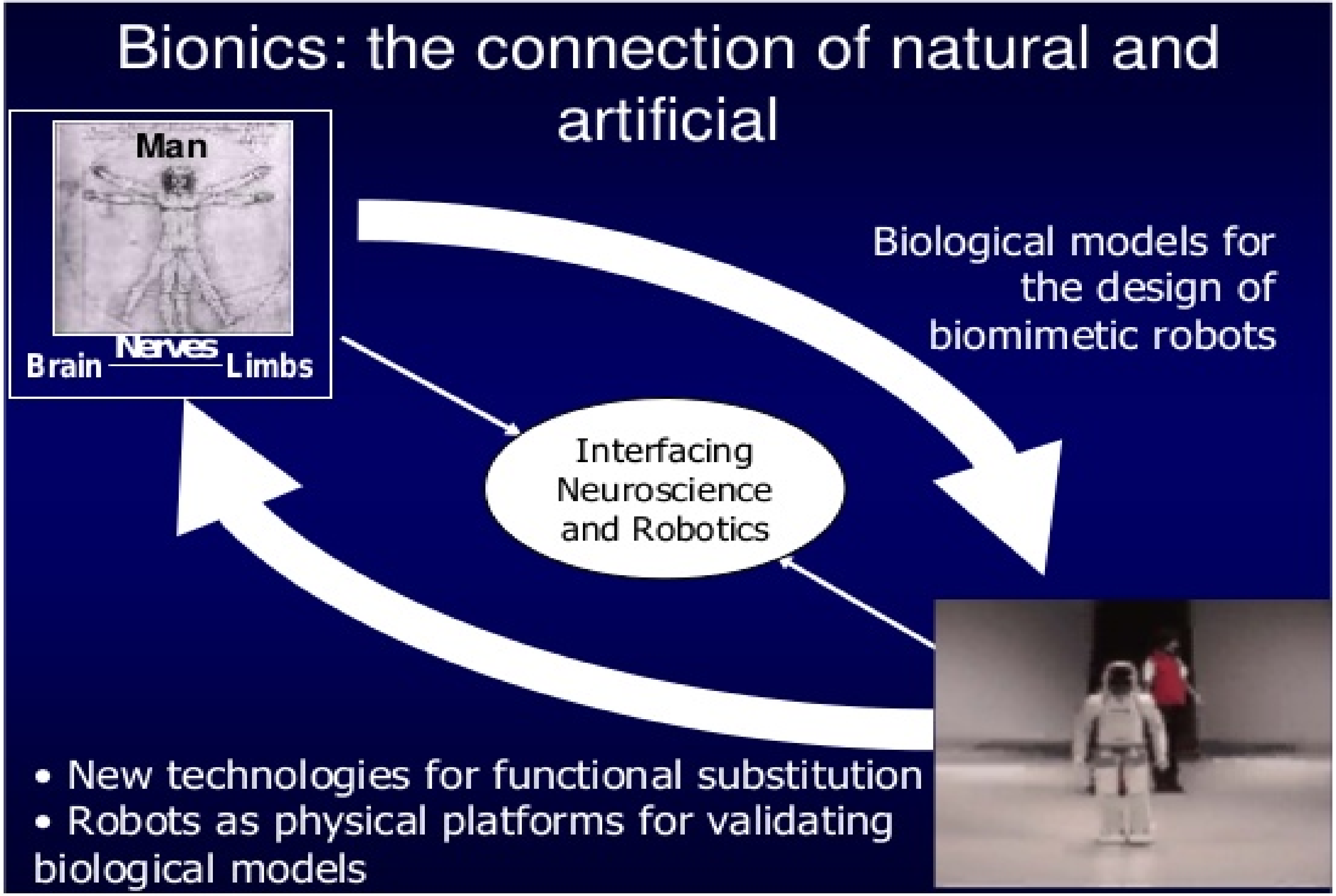
- Interdisciplinary programs – ME, EE, CSE (AI), Bio-medical
- New innovations and IP in sensors, algorithms
- New definitions of safety, programmability
- Adaptable intelligent behaviour


How daily life support systems will change society through fusion of IRT
Science and core technology
- Smooth communication between humans and computers using the five senses and body movements
- Understanding of purpose of human actions
- Fusion of recognition, learning and movement
- Bio-machine interface
Platforms
- Humanoids
- Social and daily life support systems
- Personal mobility devices
IRT
For transmission and communication, computers will be able to process information at higher speeds and with greater efficiency.
Robot technology will become more practical, reliable, and useful.
IT: Information Technology (in cyber world)
X
RT: Robot Technology (in real world)

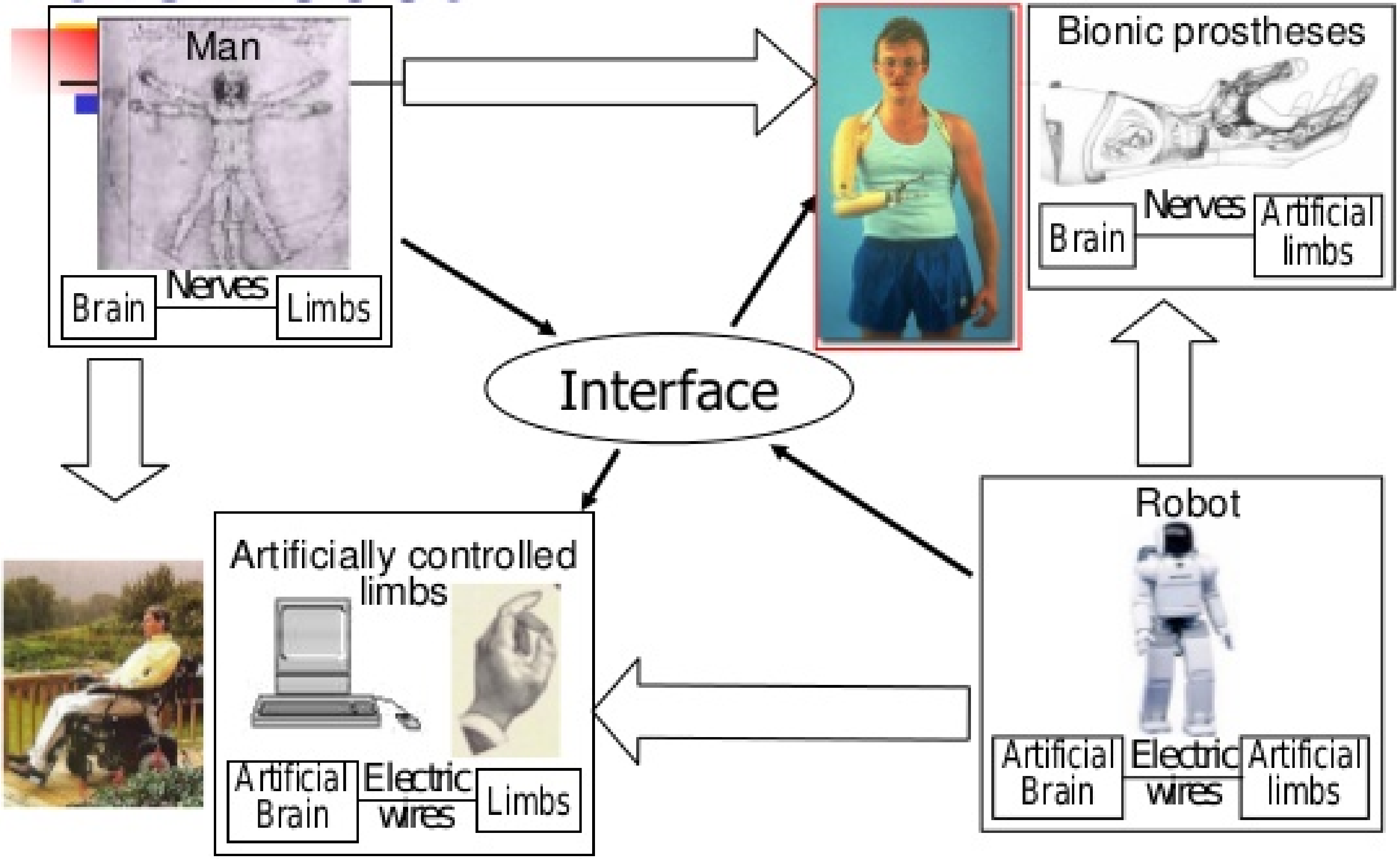
Direct Human Interaction



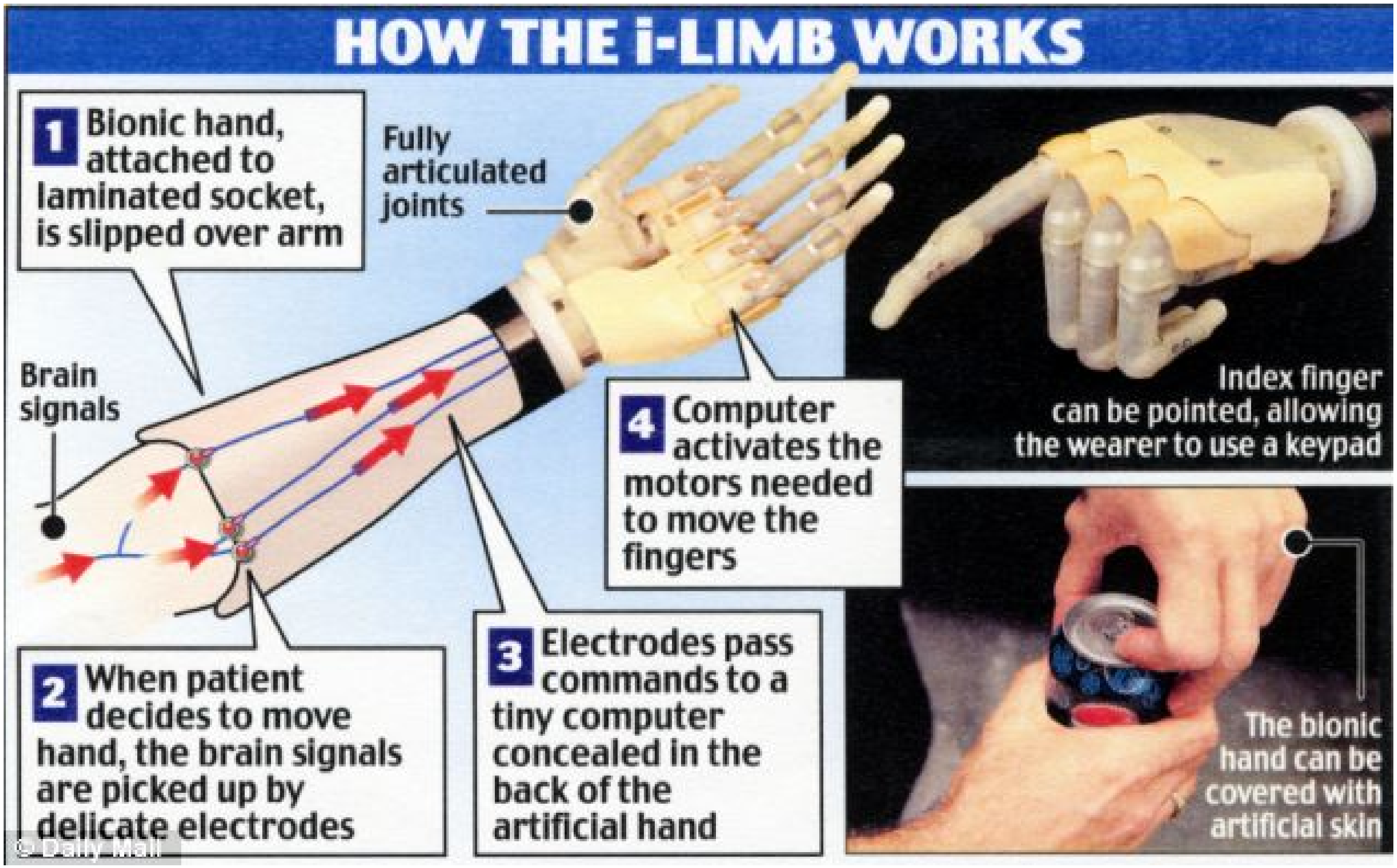
Bionics


Bionics: the connection of natural and artificial
Man
Brain
Nerves
Limbs
Biological models for the design of biomimetic robots
Interfacing Neuroscience and Robotics
• New technologies for functional substitution
• Robots as physical platforms for validating biological models

"Connecting" the Man and the Robot



Bionic Controls



Exploratory Robotics

- Remotely operated vehicles
- Autonomous vehicles
- Ground vehicles – wheeled, legged, hybrid
- Ariel Vehicles – UAVs,
- Underwater – ROVs, AUVs, UUVs
- Space Robotics
- Inter planetary rovers

Autonomous Systems

- Systems which can work on their own without external guiding inputs
- Sense and react with environment
- Decide on control actions on their own
- Intelligent systems
- Autonomous Robots
- Autonomous Vehicles

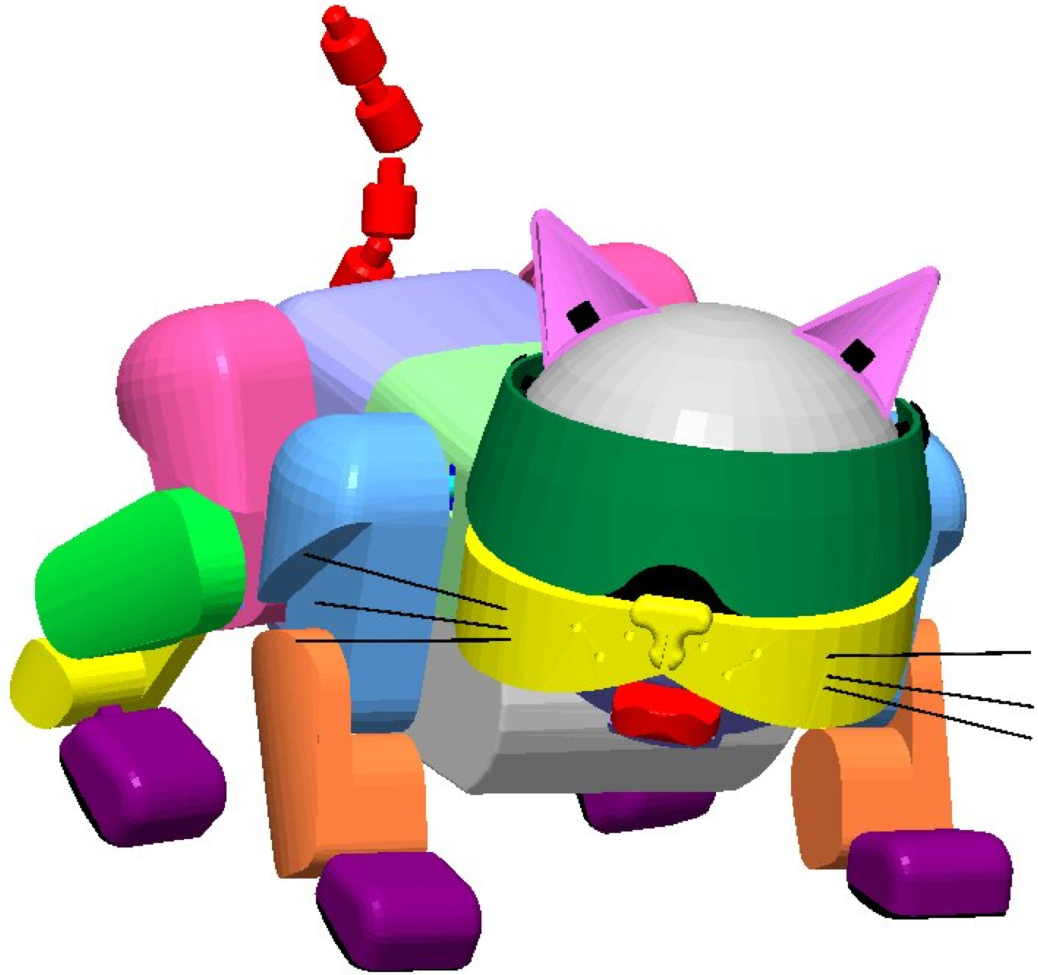
Typical Areas Covered

- Sensors and Control in Mechatronics and Robotics
- Electronics for Mechanical Engineers
- Mechanical Engineering for Electronics Engineers
- Robotic Control and Networking
- Example cases of IIT Kharagpur
  - Underwater Robotics
  - Multi fingered hand
  - Humanoid Robots

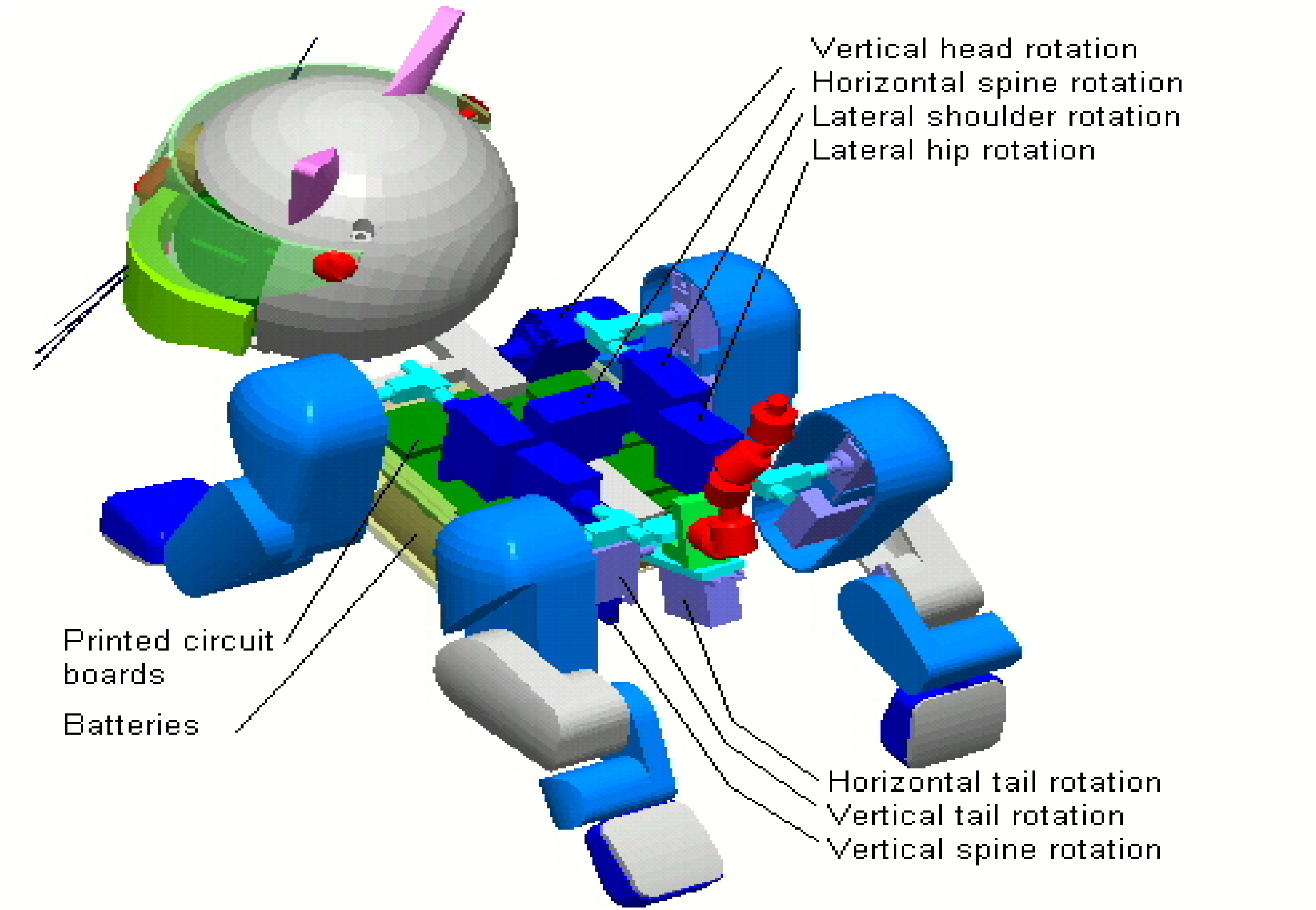
Desire to build Intelligent Systems

- Robot Child Cat “Robokoneko” at ATR Labs
  - CAMBrain Project
- Honda ASIMO
  - Humanoid mobility
- SONY Aibo
  - Intelligent Dog
- Fujitsu HOAP; Aldebran Nao
- ….

Robokoneko (robot kitten)

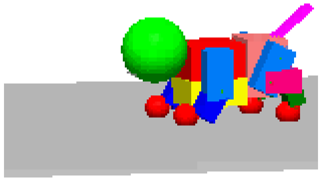


Mechanical design



Activities it can do

Walk



Steer

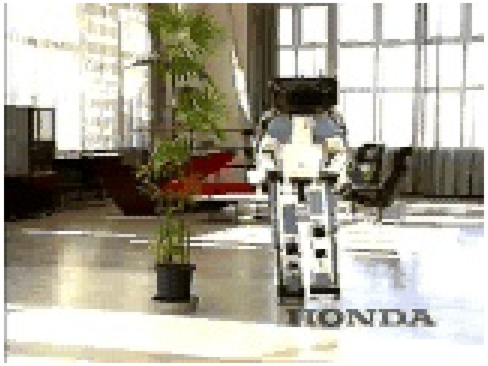
Jump

Programmed using Cellular Neural Networks

Unsupervised learning from simulated models

Controller developed on a chip called “CAMBrain”

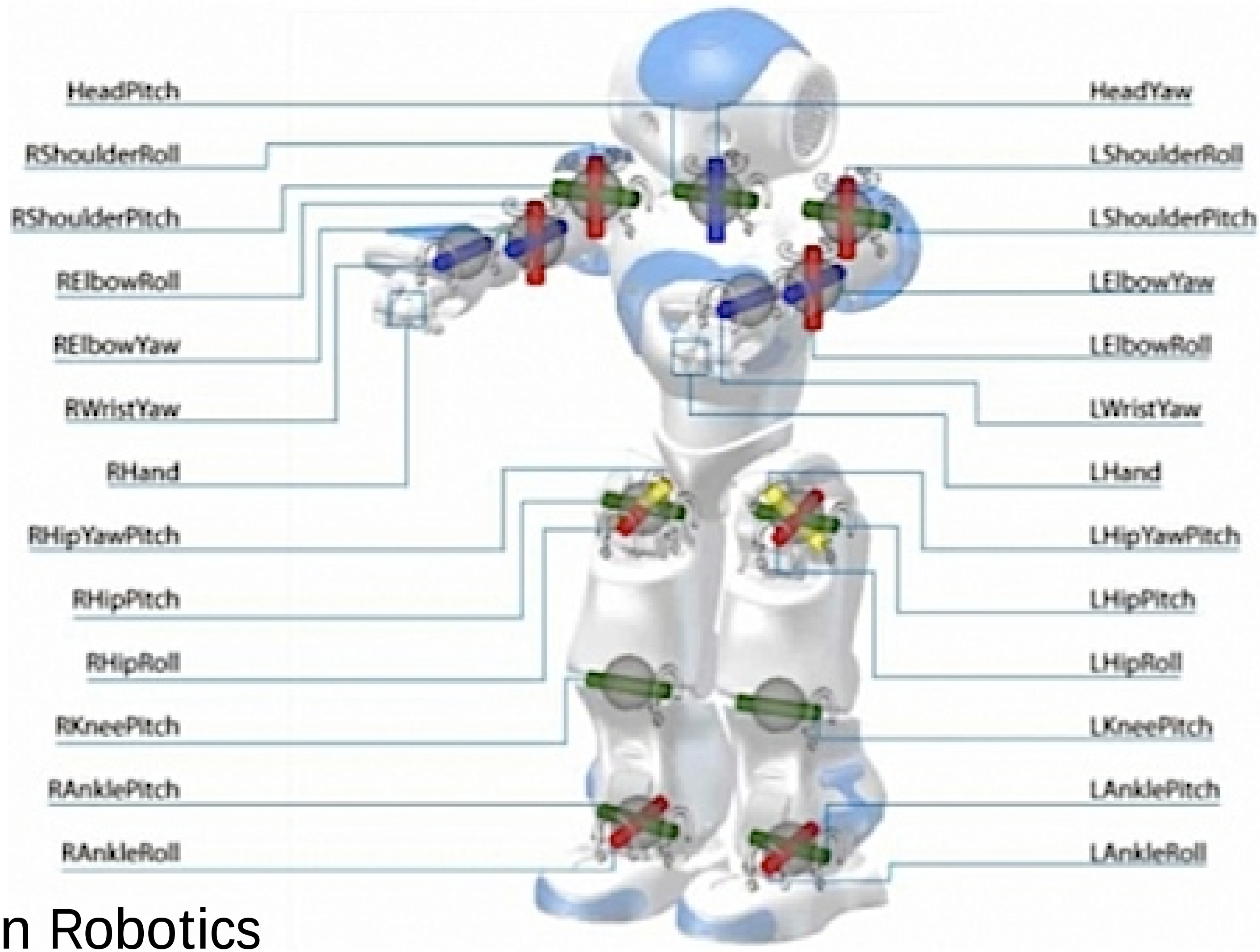
Honda Humanoid Robot Asimo



http://en.wikipedia.org/wiki/ASIMO

http://asimo.honda.com

Humanoid Robot Nao



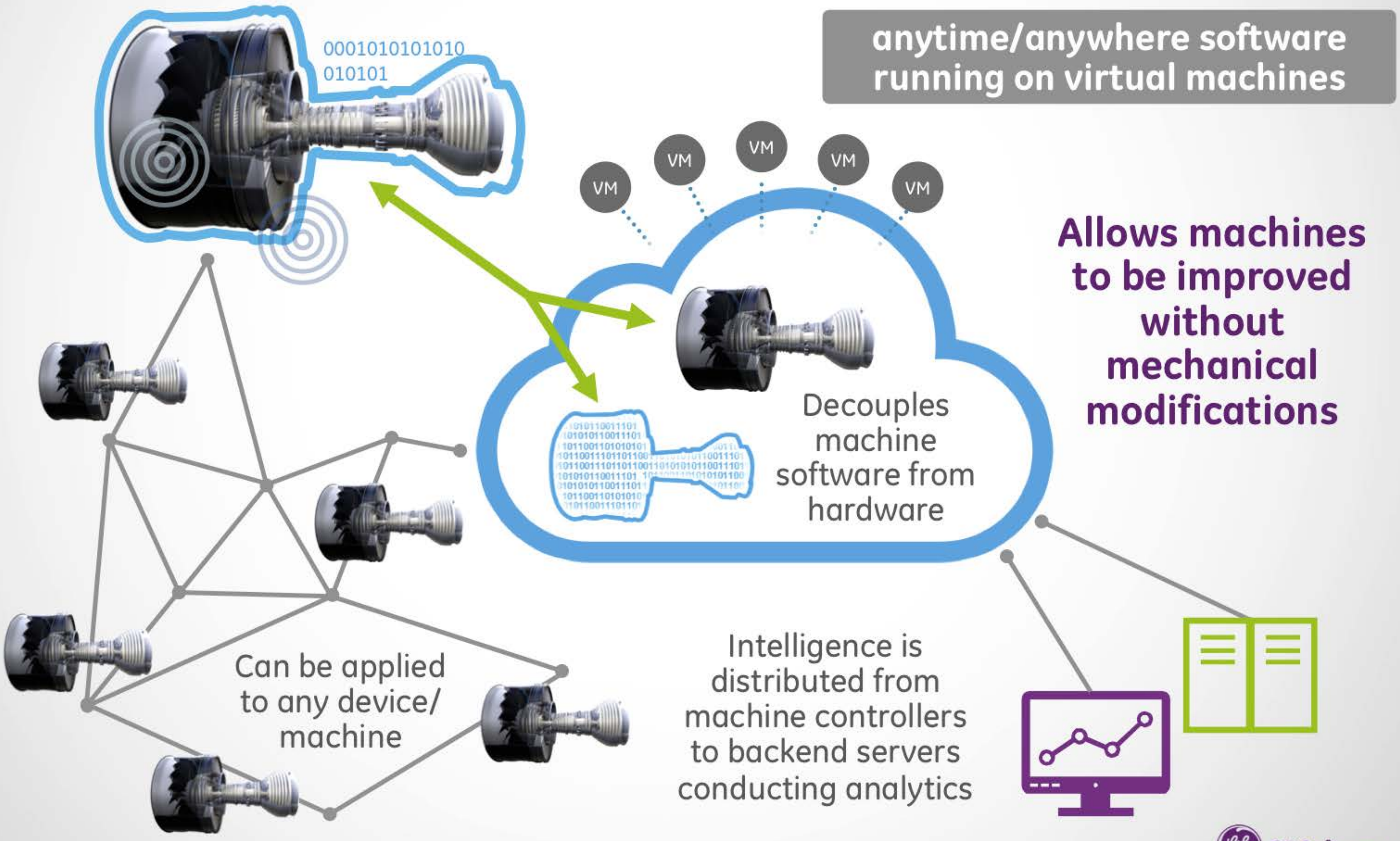
Aldebran Robotics

Kuka You Bot

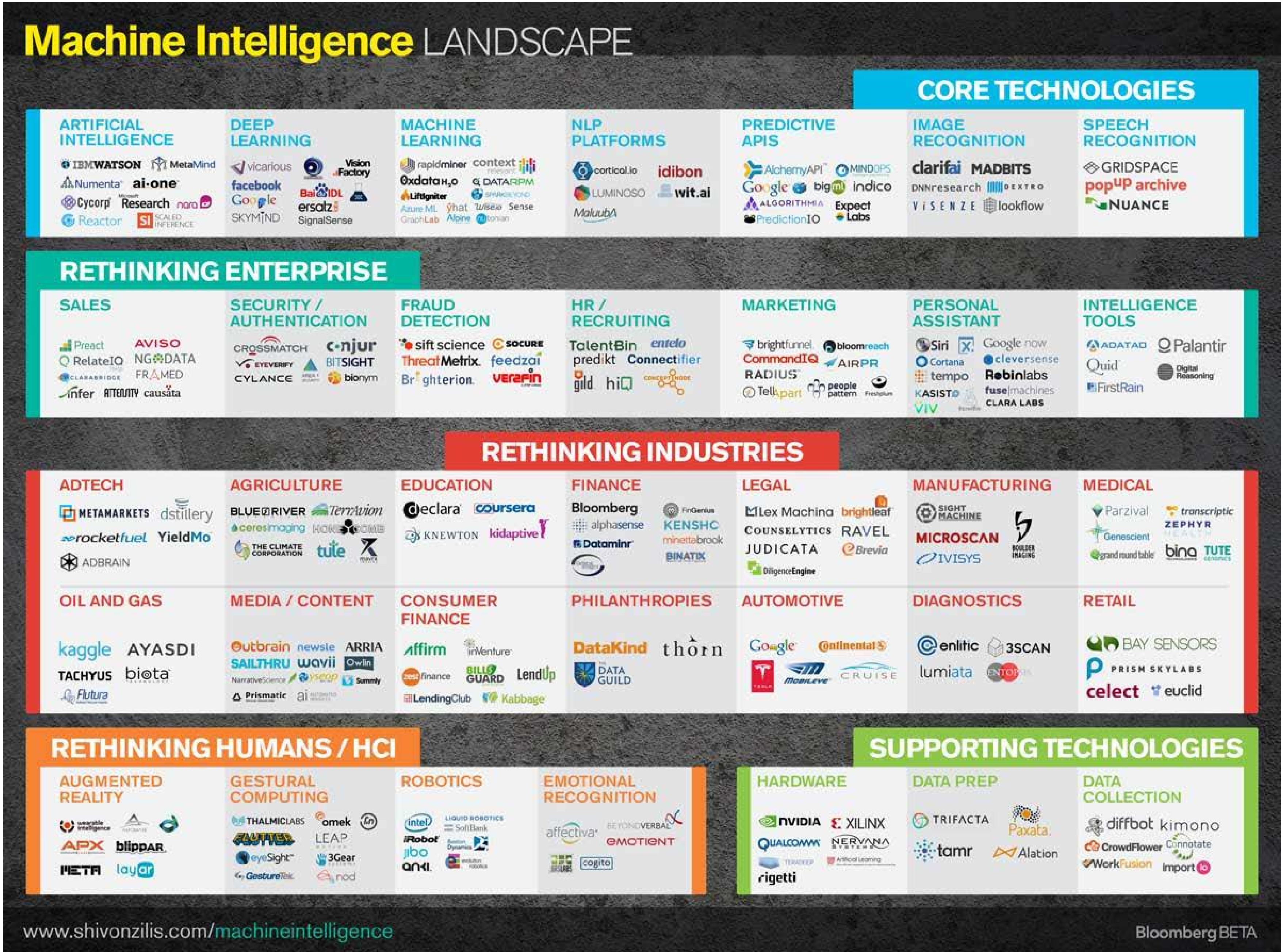
Autonomous Robots

- Respond to inputs on their own (no human intervention)
- Recovery from failures
- Embodied intelligence
- Swam robots – cooperative situations

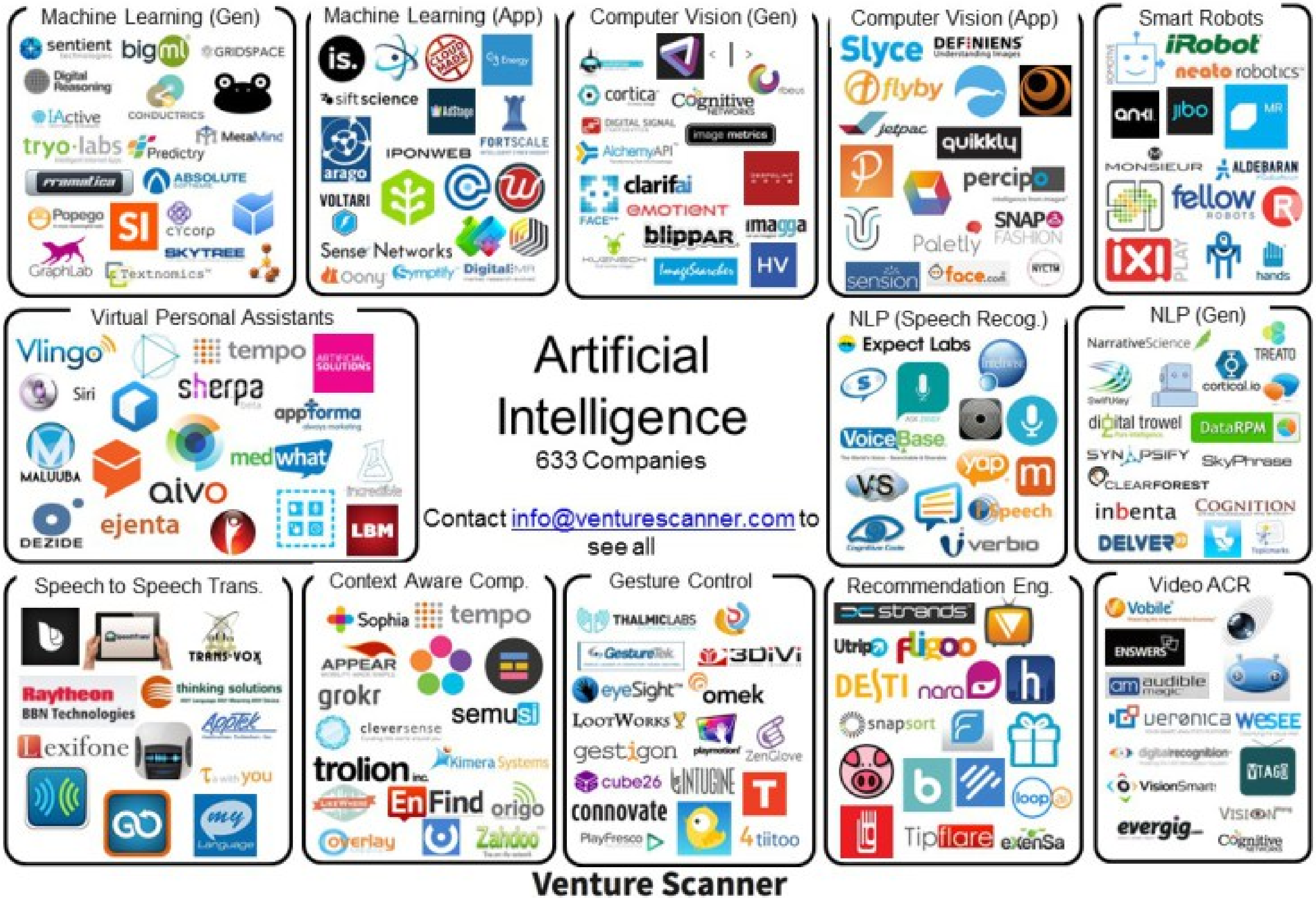
Software-defined Machines



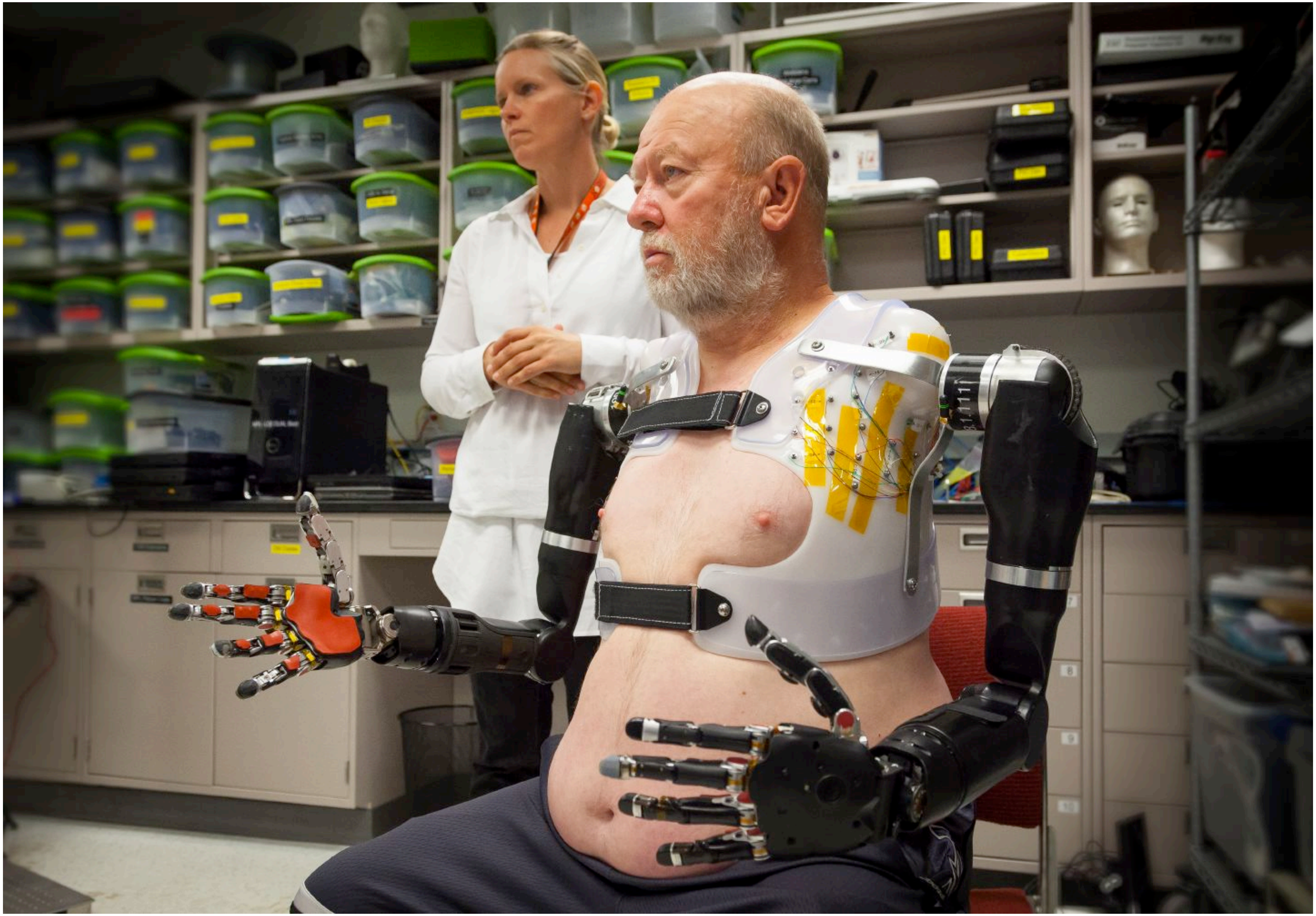
GE Software



Machine Intelligence LANDSCAPE
CORE TECHNOLOGIES
ARTIFICIAL INTELLIGENCE
IBM WATSON
MetaMind
Numenta
ai-one
Cycorp
Research
Reactor
SCALED INFERENCE
DEEP LEARNING
vicarious
Vision Factory
facebook
Baidu IDL
Google
ersatz
SKYMIND
SignalSense
MACHINE LEARNING
rapidminer
context relevant
0xdata H2O
DATARPM
Liftigniter
SPARKBEYOND
Azure ML
Yhat
Wise.io
Sense
GraphLab
Alpine
Nutonian
NLP PLATFORMS
cortical.io
idibon
LUMINOSO
wit.ai
MaluubA
PREDICTIVE APIS
AlchemyAPI
MINDOPS
Google
bigml
indico
ALGORITHMIA
Expect Labs
PredictionIO
IMAGE RECOGNITION
clarifai
MADBITS
DNNresearch
DEXTRO
VISENZE
lookflow
SPEECH RECOGNITION
GRIDSPACE
popup archive
NUANCE
RETHINKING ENTERPRISE
SALES
Preact
AVISO
RelateIQ
NGDATA
CLARABRIDGE
FRAMED
infer
ATTENTITY
causata
SECURITY / AUTHENTICATION
CROSSMATCH
cynju
EYEVERIFY
BITSIGHT
CYLANCE
bionym
FRAUD DETECTION
sift science
SOCURE
ThreatMetrix
feedzai
Brighterion
verafin
HR / RECRUITING
TalentBin
entelo
prediKt
Connectifier
gild
hiQ
MARKETING
brightfunnel
bloomreach
CommandIQ
AIRPR
RADIUS
TellApart
people pattern
Freshplum
PERSONAL ASSISTANT
Siri
x.ai
Google now
Cortana
clever sense
tempo
Robinlabs
KASISTO
fuse|machines
CLARA LABS
VIV
INTELLIGENCE TOOLS
ADATAO
Palantir
Quid
Digital Reasoning
FirstRain
RETHINKING INDUSTRIES
ADTECH
METAMARKETS
dstillery
rocketfuel
YieldMo
ADBRAIN
AGRICULTURE
BLUERIVER
TerrAvion
ceresimaging
THE CLIMATE CORPORATION
tule
EDUCATION
declara
coursera
KNEWTON
kidaptive
FINANCE
Bloomberg
FinGenius
alphasense
KENSHO
minettabrook
Dataminr
BINATIX
LEGAL
Lex Machina
brightleaf
COUNSELYTICS
RAVEL
JUDICATA
Brevia
DiligenceEngine
MANUFACTURING
SIGHT MACHINE
MICROSCAN
BOULDER IMAGING
IVISYS
MEDICAL
Parzival
transcriptic
ZEPHYR HEALTH
Genescient
grand round table
bina
TUTE GENOMICS
OIL AND GAS
kaggle
AYASDI
TACHYUS
biota
Flutura
MEDIA / CONTENT
Outbrain
newsle
ARRIA
SAILTHRU
wavii
Owlin
NarrativeScience
Summly
Prismatic
CONSUMER FINANCE
Affirm
inVenture
zestfinance
BILLGUARD
LendUp
LendingClub
Kabbage
PHILANTHROPIES
DataKind
thorn
DATA GUILD
AUTOMOTIVE
Google
Continental
TESLA
MOBILEYE
CRUISE
DIAGNOSTICS
enlitic
3SCAN
lumiata
RETAIL
BAY SENSORS
PRISM SKYLABS
celect
euclid
RETHINKING HUMANS / HCI
AUGMENTED REALITY
APX
blippar
META
layar
GESTURAL COMPUTING
THALMICLABS
omek
FLUTTER
LEAP MOTION
eyeSight
3Gear
GestureTek
nod
ROBOTICS
intel
LIQUID ROBOTICS
SoftBank
iRobot
Boston Dynamics
jibo
anki
EMOTIONAL RECOGNITION
affectiva
BEYOND VERBAL
EMOTIENT
cogito
SUPPORTING TECHNOLOGIES
HARDWARE
NVIDIA
XILINX
QUALCOMM
NERVANA
rigetti
DATA PREP
TRIFACTA
Paxata
tamr
Alation
DATA COLLECTION
diffbot
kimono
CrowdFlower
Connotate
WorkFusion
import io
www.shivonzilis.com/machineintelligence
Bloomberg BETA



Machine Learning (Gen)
sentient
bigml
GRIDSPACE
Digital Reasoning
CONDUCTRICS
iActive
tryo-labs
Predictry
MetaMind
ABSOLUTE
Popego
SI
cycorp
SKYTREE
GraphLab
Textnomics
Machine Learning (App)
is.
sift science
AdStage
FORTSCALE
arago
IPONWEB
VOLTARI
Sense Networks
Oony
Symptify
DigitalMR
Computer Vision (Gen)
cortica
Cognitive Networks
DIGITAL SIGNAL
image metrics
AlchemyAPI
clarifai
FACE++
EMOTIENT
imagga
blippAR
ImageSearcher
HV
Computer Vision (App)
Slyce
DEFINIENS
flyby
jetpac
quikkly
percipio
SNAP FASHION
Paletly
sension
face.com
Smart Robots
iRobot
neato robotics
anki
jibo
MR
MONSIEUR
ALDEBARAN
fellow ROBOTS
PLAY
hands
Virtual Personal Assistants
Vlingo
tempo
ARTIFICIAL SOLUTIONS
Siri
sherpa
appforma
MALUUBA
medwhat
incredible
aivo
DEZIDE
ejenta
LBM
Artificial Intelligence
633 Companies
Contact info@venturescanner.com to see all
NLP (Speech Recog.)
Expect Labs
VoiceBase
yap
m
VS
Speech
verbio
NLP (Gen)
NarrativeScience
TREATO
SwiftKey
cortical.io
digital trowel
DataRPM
SYNAPSIFY
SkyPhrase
CLEARFOREST
inbenta
COGNITION
DELVER
Speech to Speech Trans.
TRANS-VOX
Raytheon BBN Technologies
thinking solutions
AppTek
Lexifone
Talk with you
my Language
Context Aware Comp.
Sophia
tempo
APPEAR
grokr
semusi
cleversense
trolion inc.
Kimera Systems
EnFind
origo
overlay
Zahdoo
Gesture Control
THALMICLABS
GestureTek
3DiVi
eyeSight
omek
LootWorks
playmotion!
gestigon
ZenGlove
cube26
INTUGINE
connovate
PlayFresco
4tiitoo
Recommendation Eng.
strands
Utrip
fligoo
DESTI
nara
h
snapsort
b
loop ai
Tipflare
exensa
Video ACR
Vobile
ENSWERS
audible magic
veronica
WESEE
digitalrecognition
VisionSmart
TAGS
evergig
VISION
Cognitive
Venture Scanner



Robots in our life







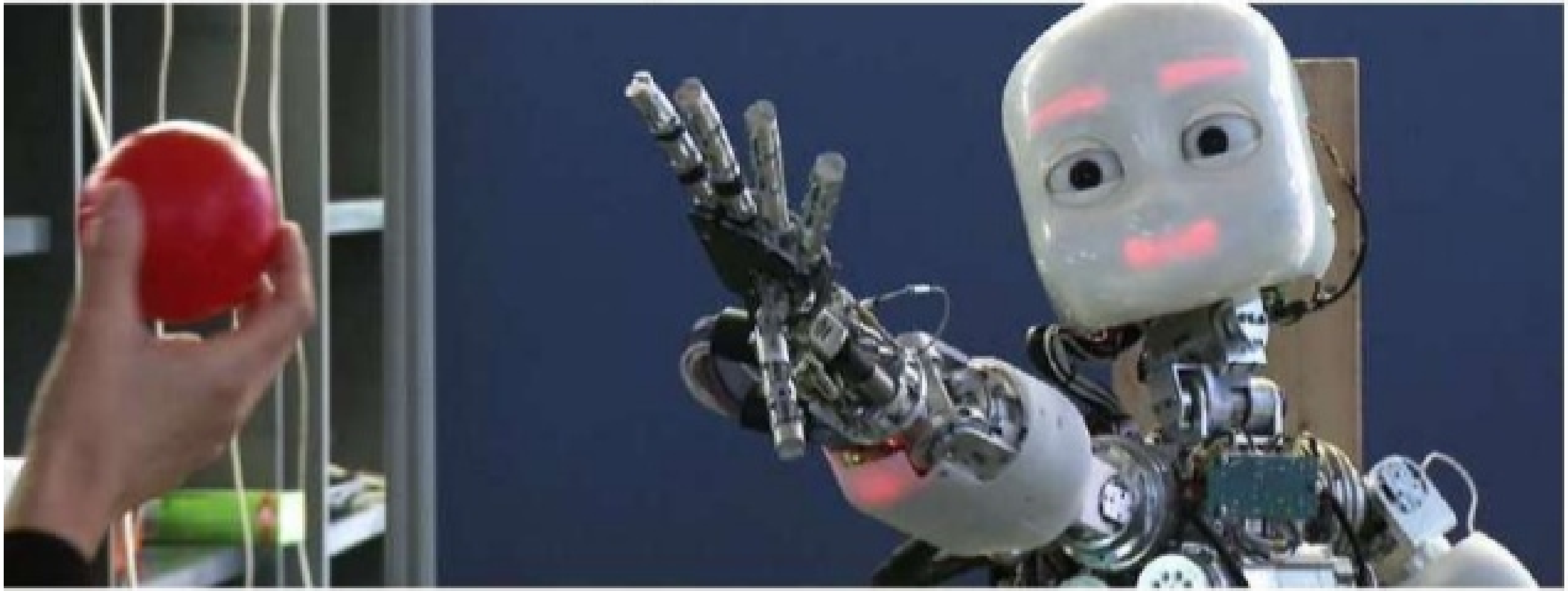

RoboCup

By the year 2050,
develop a team of fully
autonomous humanoid robots
that can win against the human
world soccer champion team.

U.S. National Robotics Initiative

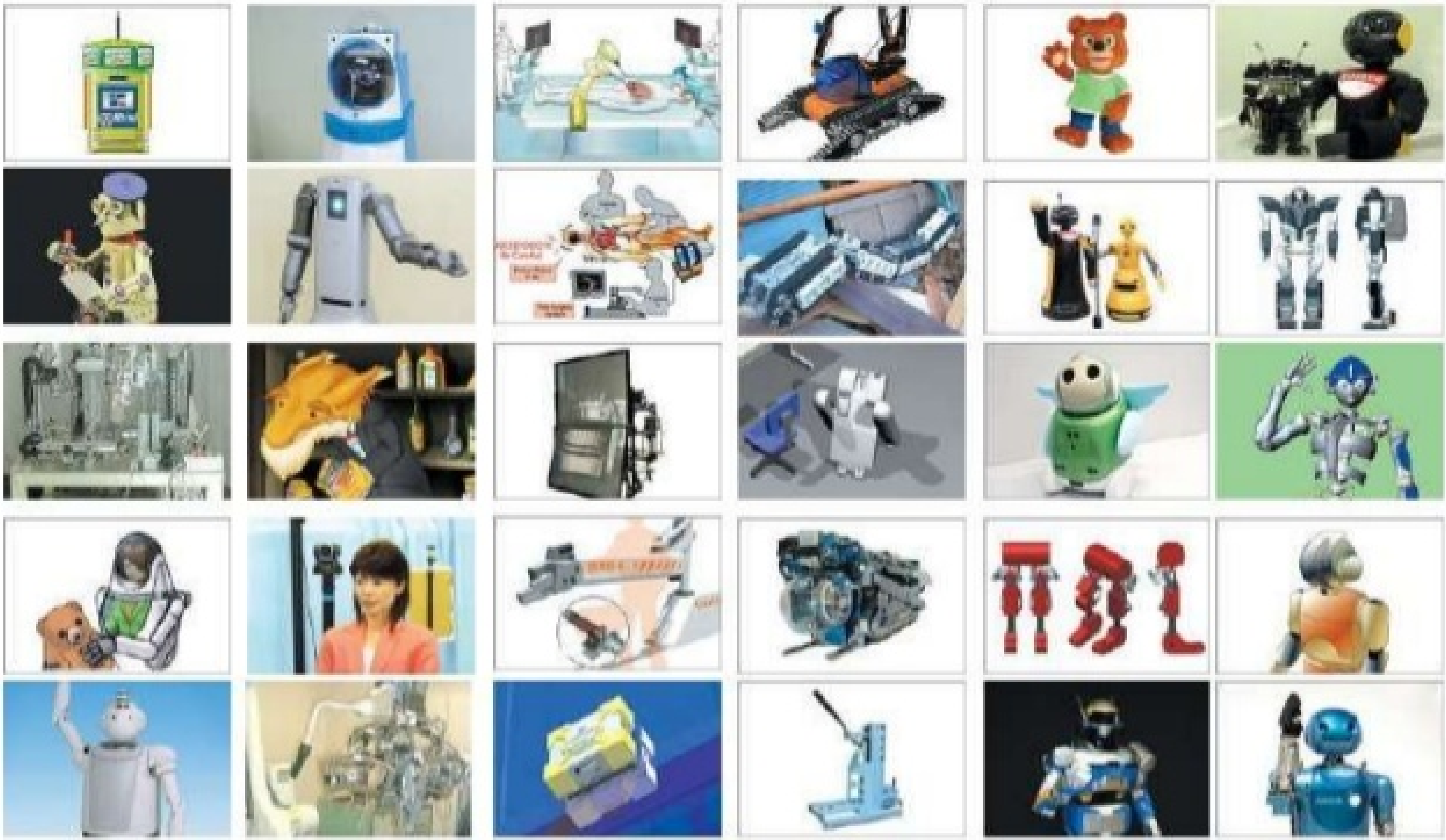
- "Obama Commanding Robot Revolution, Announces Major Robotics Initiative"
  - June 2011
  - The administration's new National Robotics Initiative seeks to advance "next generation robotics." The focus is on robots that can work closely with humans—helping factory workers, healthcare providers, soldiers, surgeons, and astronauts to carry out tasks.

European Vision



- Robot Companions for Citizens
  - an ecology of sentient machines that will help and assist humans in the broadest possible sense to support and sustain our welfare.

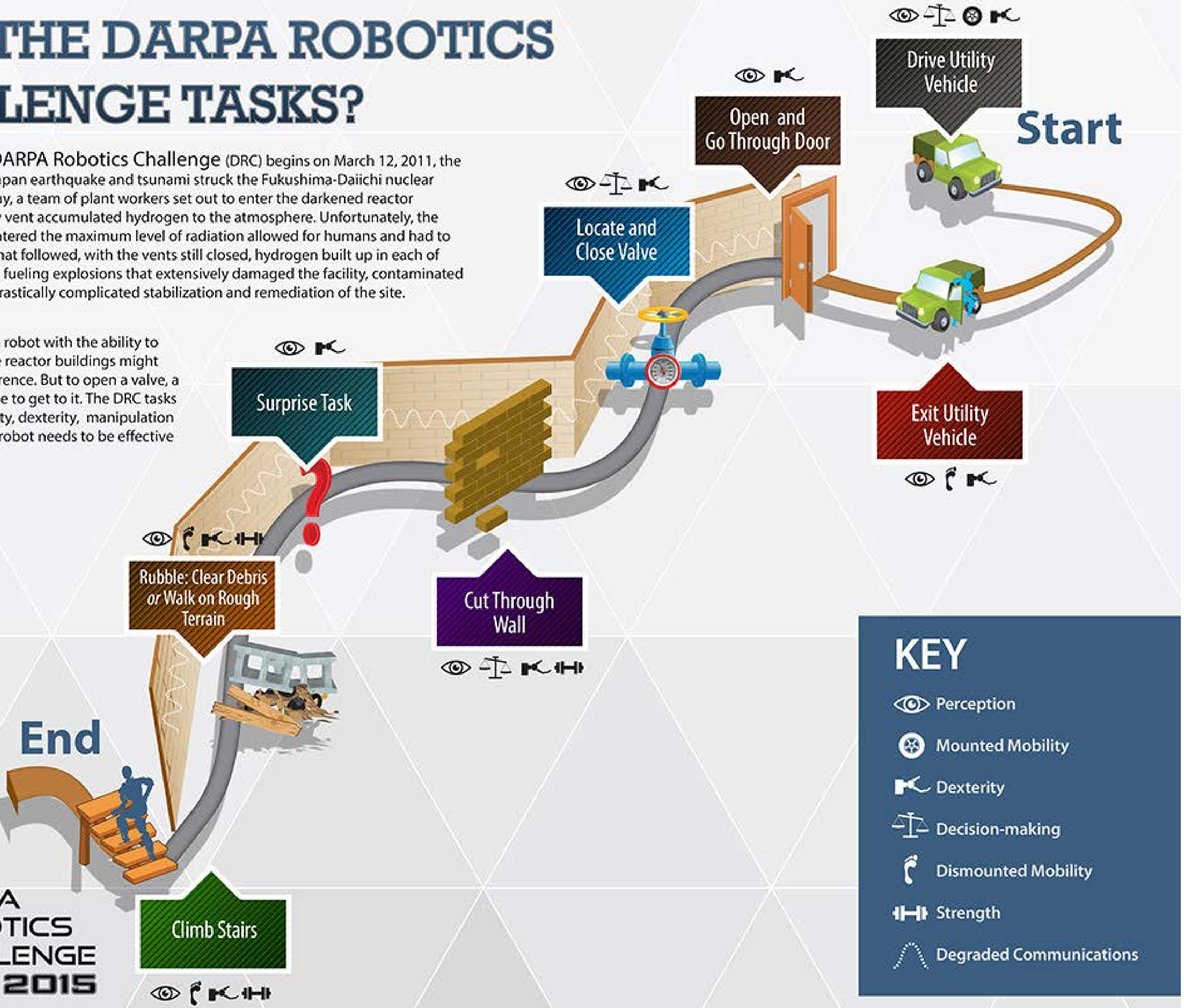
Robot City 2020



WHY THE DARPA ROBOTICS CHALLENGE TASKS?

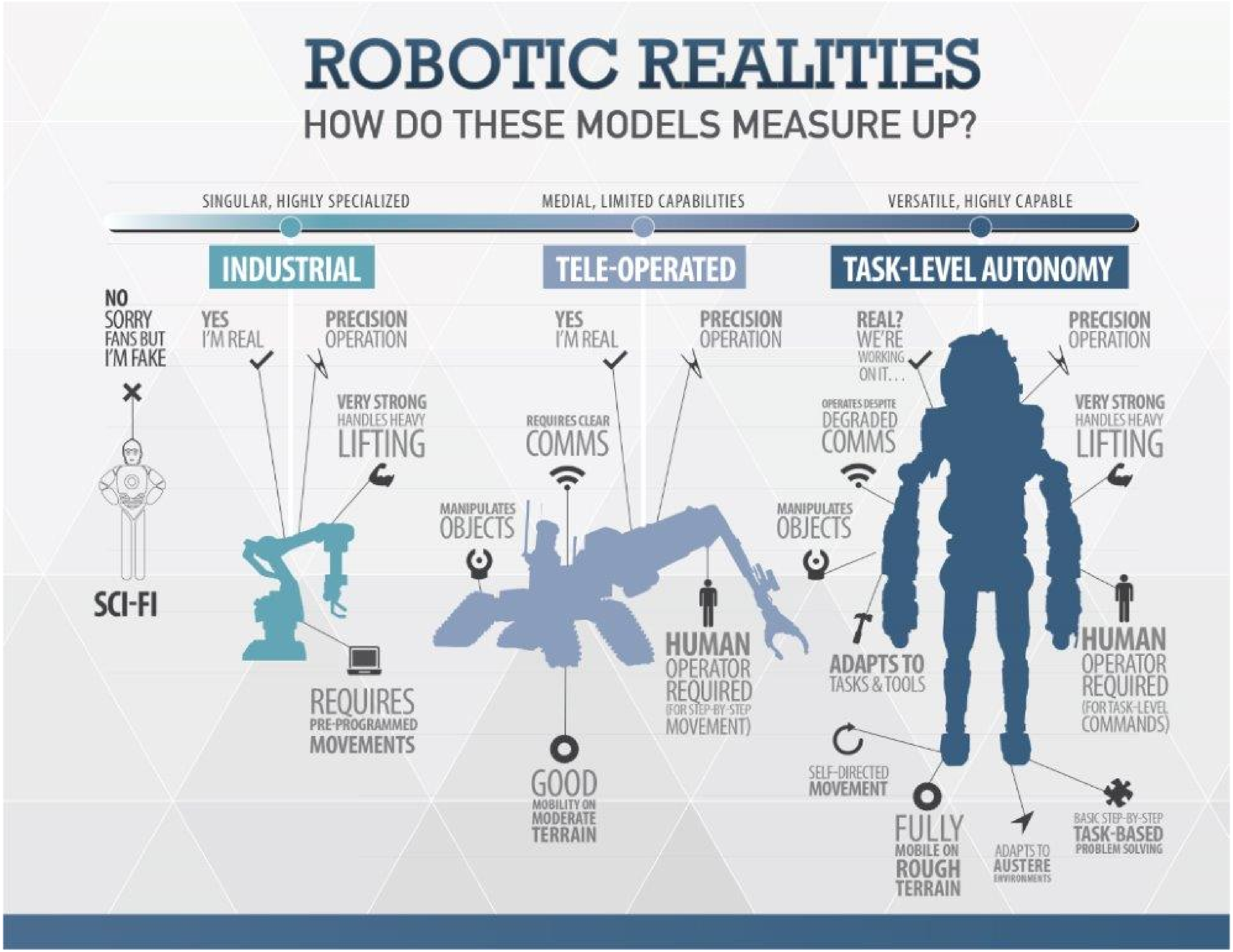
The story of the DARPA Robotics Challenge (DRC) begins on March 12, 2011, the day after the Tohoku, Japan earthquake and tsunami struck the Fukushima-Daiichi nuclear power plant. On that day, a team of plant workers set out to enter the darkened reactor buildings and manually vent accumulated hydrogen to the atmosphere. Unfortunately, the vent team soon encountered the maximum level of radiation allowed for humans and had to turn back. In the days that followed, with the vents still closed, hydrogen built up in each of three reactor buildings, fueling explosions that extensively damaged the facility, contaminated the environment and drastically complicated stabilization and remediation of the site.

At Fukushima, having a robot with the ability to open valves to vent the reactor buildings might have made all the difference. But to open a valve, a robot first has to be able to get to it. The DRC tasks test some of the mobility, dexterity, manipulation and perception skills a robot needs to be effective in disaster response.



DARPA

DARPA ROBOTICS CHALLENGE FINALS 2015


ROBOTIC REALITIES
HOW DO THESE MODELS MEASURE UP?
SINGULAR, HIGHLY SPECIALIZED
MEDIAL, LIMITED CAPABILITIES
VERSATILE, HIGHLY CAPABLE
INDUSTRIAL
TELE-OPERATED
TASK-LEVEL AUTONOMY
NO SORRY FANS BUT I'M FAKE
SCI-FI
YES I'M REAL
PRECISION OPERATION
VERY STRONG HANDLES HEAVY LIFTING
REQUIRES PRE-PROGRAMMED MOVEMENTS
YES I'M REAL
PRECISION OPERATION
REQUIRES CLEAR COMMS
MANIPULATES OBJECTS
HUMAN OPERATOR REQUIRED (FOR STEP-BY-STEP MOVEMENT)
GOOD MOBILITY ON MODERATE TERRAIN
REAL? WE'RE WORKING ON IT...
PRECISION OPERATION
OPERATES DESPITE DEGRADED COMMS
VERY STRONG HANDLES HEAVY LIFTING
MANIPULATES OBJECTS
ADAPTS TO TASKS & TOOLS
HUMAN OPERATOR REQUIRED (FOR TASK-LEVEL COMMANDS)
SELF-DIRECTED MOVEMENT
FULLY MOBILE ON ROUGH TERRAIN
ADAPTS TO AUSTERE ENVIRONMENTS
BASIC STEP-BY-STEP TASK-BASED PROBLEM SOLVING

TEAM KAIST

TEAM MIT

TEAM NEDO-HYDRA

TEAM NEDO-JSK

TEAM NIMBRO RESCUE

TEAM ROBOSIMIAN

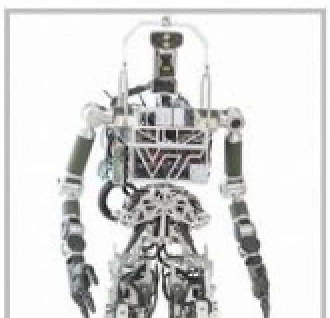
TEAM ROBOTIS

TEAM SNU

TEAM THOR

TEAM TRAC LABS

TEAM TROOPER



TEAM VALOR

TEAM VIGIR

TEAM WALK-MAN

TEAM WPI-CMU

New Applications being considered

- The future of the internet is intelligent machines *by* Jeff Immelt, Chairman and CEO of GE (on 28th Nov 2012)
- *Internet of Things*
- *Socially Intelligent Machines Lab (Georgia Tech)*
- *Super Intelligent Machines (Live Science*

Summary

- Intelligent Systems: Basic needs highlighted
- Precision verses adaptability discussed
- Types of implementations highlighted
- Focus on Connectionistic learning, Knowledge based sytems etc
- Case for Robotics
- Examples in Robotics