International Robot High School

An ABCs of Industrial Robot

産業用ロボットのイロハ

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Tsukuba Research Laboratory
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Mechatronics

"Mechanics" + "Electronics" ⇒ "Mechatronics"

機械工学　　電子工学

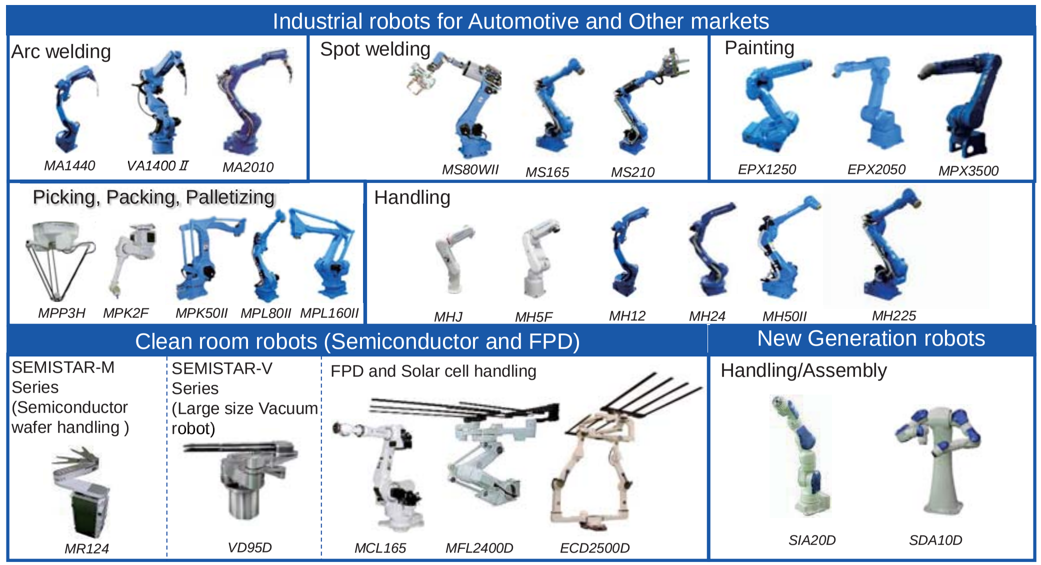
"Mechatronics" was applied for trademark of Yaskawa in 1969.

It was registered in 1972.

Applications of Robot

- Arc Welding
- Spot Welding
- Painting
- Handling
- Picking, Packing, Palletizing (3P)
- Assembly
- FPD glass Handling
- Semiconductor wafer handling

Industry Robot Product Line



Main products of Robotics Segment

Arc Welding

Ultra-Low Spatter with Motopac Package

RL350 + EAGL method

* EAGL : Enhanced Arc weldinG for Low spatter

MA series
MA1440

MIG・ MAG Welding (Pulse arc welding)

Jigless Coordinate Welding System

Spot Welding

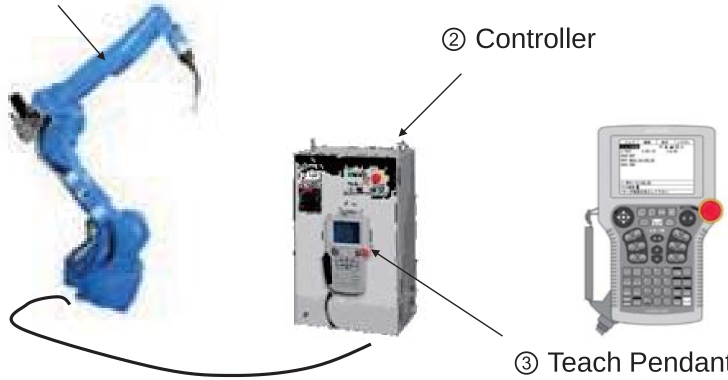
Faster Speed/ Slim Profile for High Density Installation

MS series
MS165 / MS210

MS165/ MS210 Features
Reduced up to 35 % cycle time compared to previous ES165/200D robot model.
High-speed robot motion which reduces air cut time etc.

Car Production Line
Spot Welding System
(image)

Components of the Industrial Robot System



Type of the Industrial Robot

Vertical Articulated Robot   Horizontal Articulated Robot   Parallel Link Robot

End Effecter (Tool)

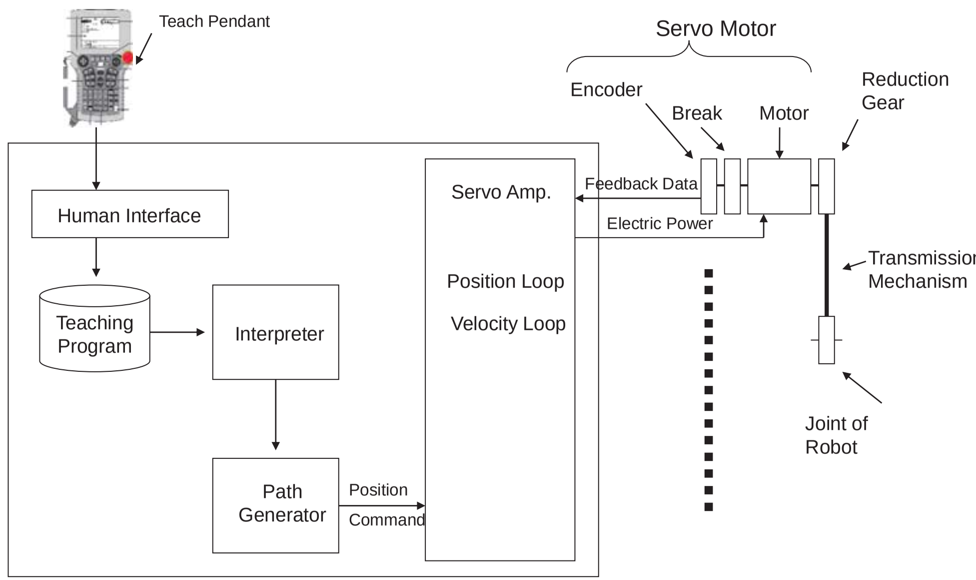
Application (Welding, Painting, etc)

DOF: Degree Of Freedom

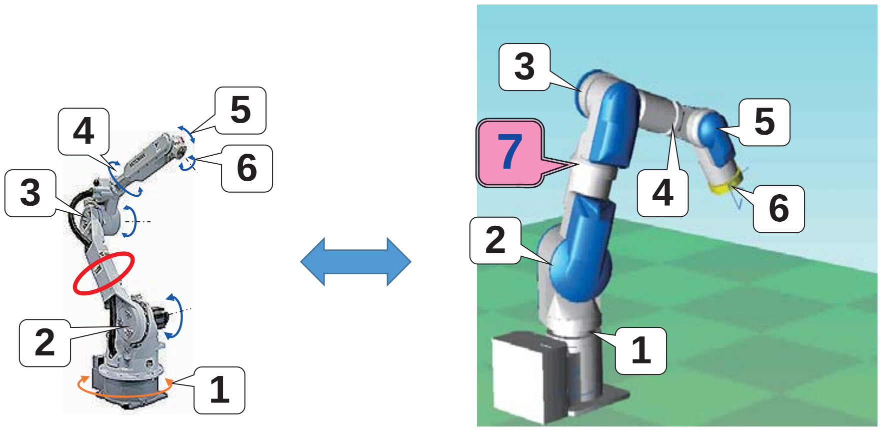
Number of Joints

Position and Orientation

Components of the Industrial Robot System



Degree Of Freedom (DOF)



6 DOF

7 DOF

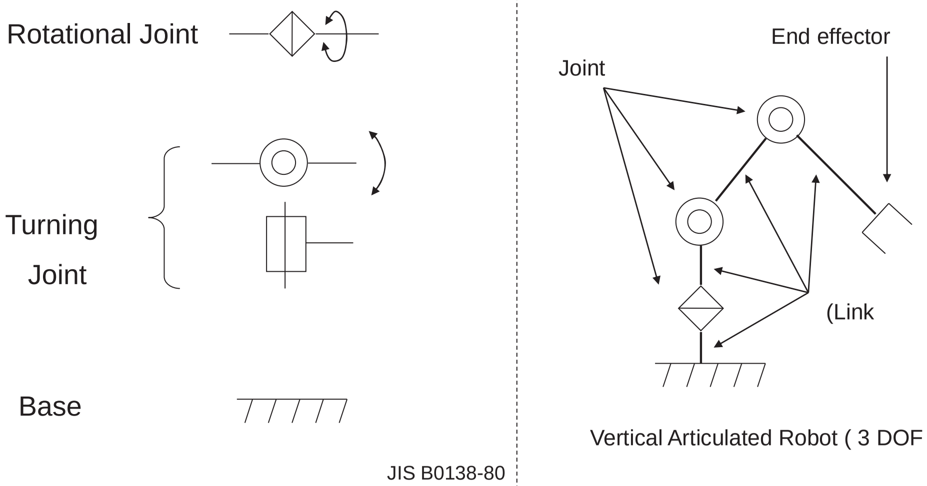
Degree Of Freedom (DOF)

6 DOF is needed to set the tool for arbitrary position and orientation In 3 dimensional space.

Q1 : How many DOF does your arm has ?
Q2 : How many DOF do you need to set arbitrary position and orientation in 2 dimensional space ?

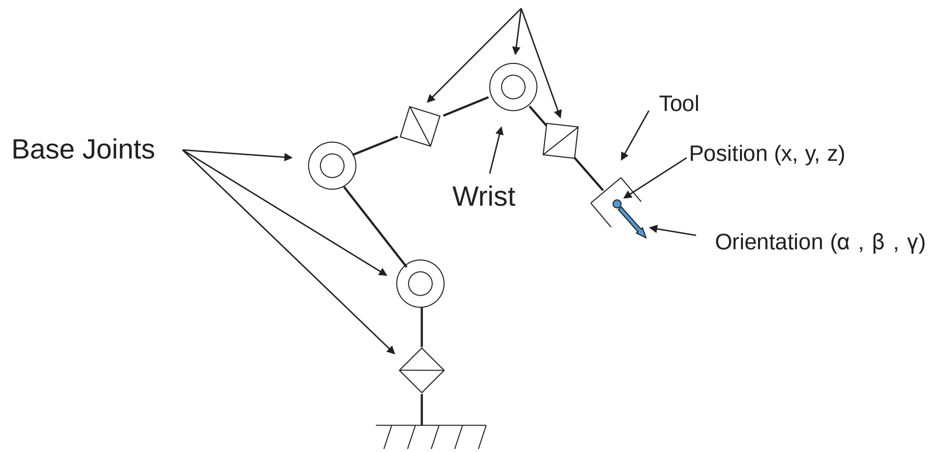
Redundancy

Symbols for Robot Model



Vertical Articulated Robot (3 DOF)

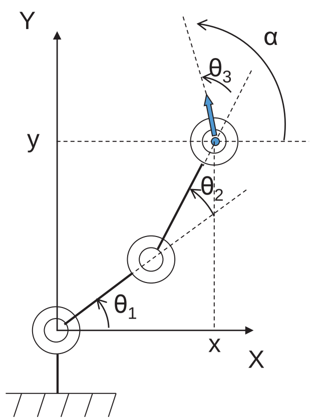
Model of 6DOF Vertical Articulated Robot

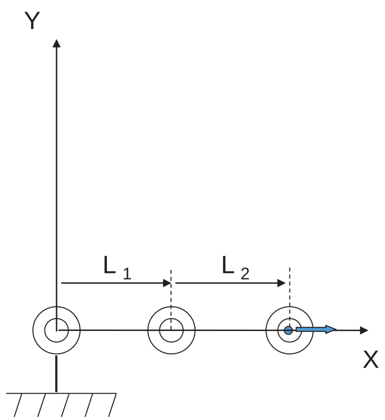


Model of 3DOF Vertical Articulated Robot

Joint Variable : θ_1 , θ_2 , θ_3

Position Variable : x , y
Orientation Variable : α



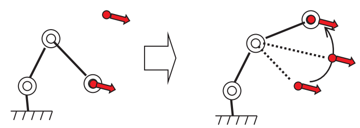


$\theta_1 = \theta_2 = \theta_3 = 0$

Basic Position Control

PTP (Point To Point Control)

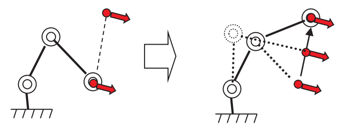
a start position and a goal position



CP (Continuous Path Control)

- a start Position and a goal position
- a path between SP and GP

- Interpolation
- path : line → Linear Interpolation
- path : arc → Circular Interpolation



Procedure of Linear Interpolation

Start Position: $\mathbf{p}_s$, Goal Positon: $\mathbf{p}_g$, Segment Time: T, Velocity: S

① $\mathbf{p}_s$: Joint Variable of $[\theta_1 , \theta_2 , \theta_3]^t$ ⇒ Posture Variable $[x_s , y_s , \alpha_s]^t$

② $\mathbf{p}_g$: Joint Variable of $[\theta_1 , \theta_2 , \theta_3]^t$ ⇒Posture Variable $[x_g , y_g , \alpha_g]^t$

③ Vector **v** = $\mathbf{p}_g$ - $\mathbf{p}_s$

④ Length of **v :** legth

⑤ Times of Interpolation: N = length / S

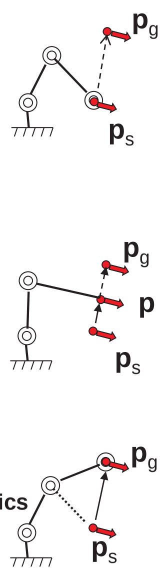
⑥ Vector **delta** = **v / N**

⑦ Temp. Variable **p** =$\mathbf{p}_s$

⑧ While (**p** != $\mathbf{p}_g$)
p = p + delta : $[x , y , \alpha]^t$
p : Posture Variable $[x , y , \alpha]^t$⇒Joint Variable $[\theta_1 , \theta_2 , \theta_3]^t$
Using PTP Control, Move Joint to **p** $[\theta_1 , \theta_2 , \theta_3]^t$

Joint Variable of $[\theta_1 , \theta_2 , \theta_3]^t$ ⇒ Posture Variable $[x_s , y_s , \alpha_s]^t$:**Forward Kinematics**

Posture Variable $[x , y , \alpha]^t$⇒Joint Variable $[\theta_1 , \theta_2 , \theta_3]^t$:**Inverse Kinematics**



Forward Kinematics

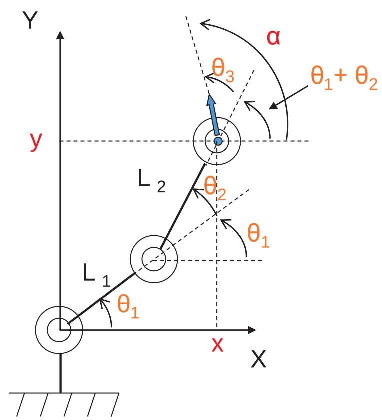
Joint Variable of $[\theta_1 , \theta_2 , \theta_3]^t$ ⇒ Posture Variable $[x , y , \alpha]^t$

$x = L_1 * \cos(\theta_1) + L_2 * \cos(\theta_1+\theta_2)$

$y = L_1 * \sin(\theta_1) + L_2 * \sin(\theta_1+\theta_2)$

$\alpha = \theta_1+\theta_2+\theta_3$

We can get Unique Answer



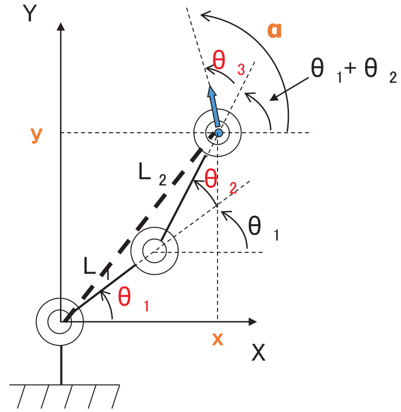
Inverse Kinematics

Posture Variable $[x, y, \alpha]^t$ → Joint Variable $[\theta_1, \theta_2, \theta_3]^t$

Algebraic Solution

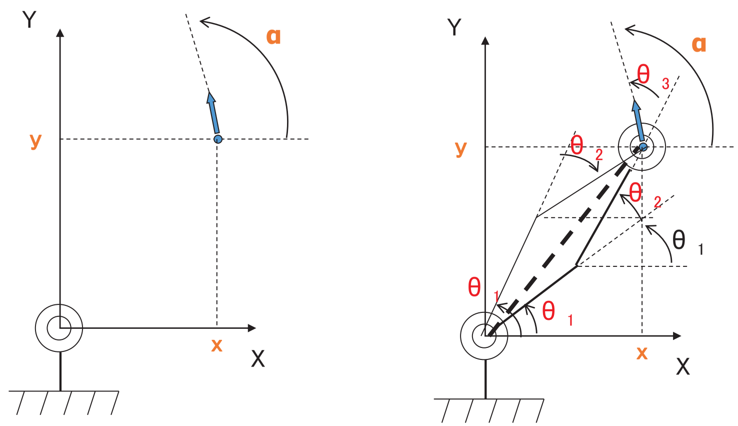
Home Work

No Guarantee of obtaining a solution



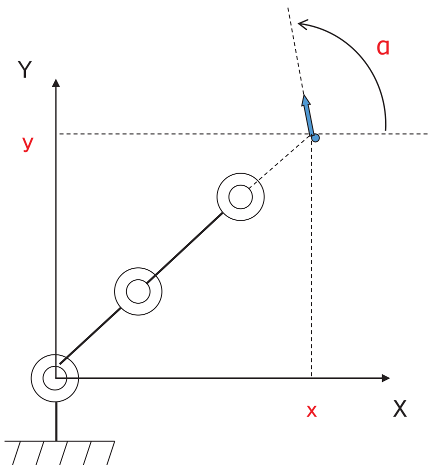
Inverse Kinematics

Case1: Multiple Solutions



Inverse Kinematics

Case2: No Solution



History of Robot Development

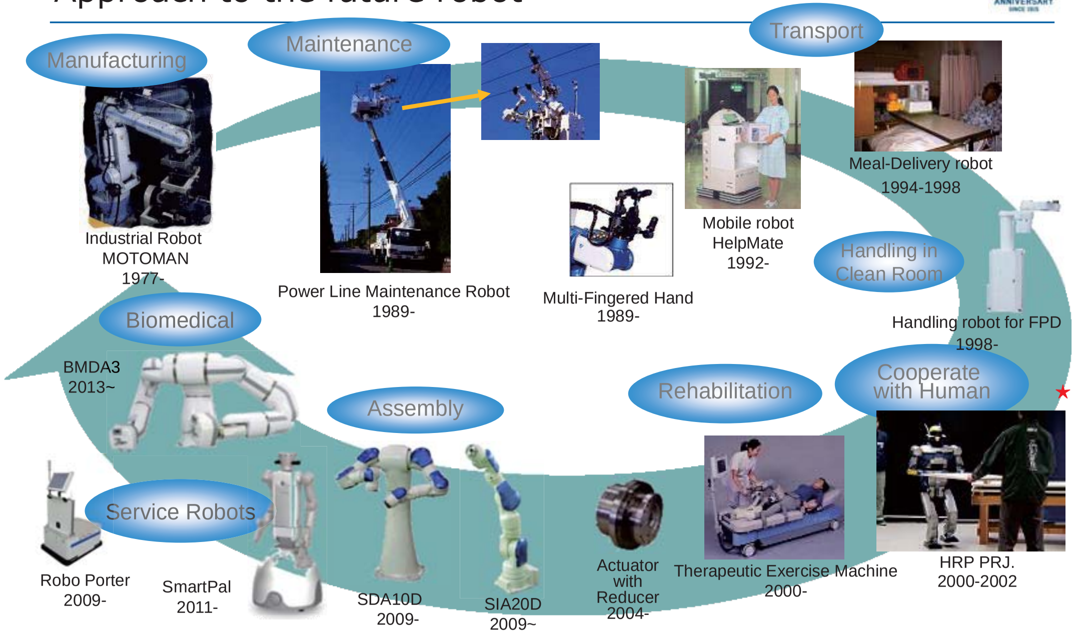
21 R.U.R (Rossum's Universal Robots) Karel Capek, Cesko-Slovensko
"Robota"

54 The First Patent of a robot, George Devol, U.S.
59 The First Industrial Robot: Unimate, Unimation, U.S.
62 Versatran, AMF, U.S.
02 Roomba (iRobot)
04 HRP-2
77 MOTOMAN L10

96 HONDA P2 (Asimo)

83 RSJ was established

Approach to the future robot



Power Line Maintenance Robot

7 DOF Arm

Operation Cabin

- Remote Operation
- Autonomous Operation

The Technical Innovations Award from RSJ (1996)

DOF : Degree Of Freedom

Humanoid Robot : HRP2

Humanoid Robotics Project by METI

Bipedal Walking Control: AIST
Design and Manufacture: KAWADA INDUSTRY
Environment Recognition: AIST, SHIMIZU CO.
Arm Control: YASKAWA

METI: Ministry of Economy, Trade and Industry
AIST: National Institute of Advanced Industrial Science and Technology

Our Vision for 2025

Offer a new value to society through fusion of core technology advancement and open innovation

Our Goal

Respect Life

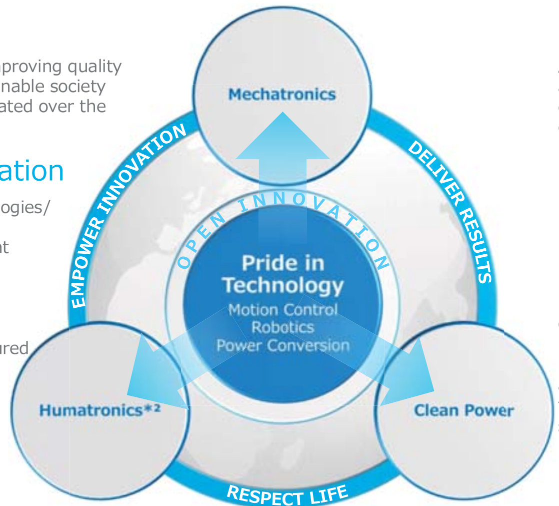
We aim to contribute to improving quality of life and building a sustainable society with technologies accumulated over the past century.

Empower Innovation

We venture in new technologies/ domains/targets to bring "Waku-Waku"*1 excitement to people.

Deliver Results

We promise to deliver assured results to stakeholders, while continuously enhancing business execution capabilities.



Our Business Domains

Mechatronics

Achieve revolutionary industrial automation, through combination of world's leading edge technologies and open innovation.

Clean Power

Provide safe and secure living in a sustainable society.

Humatronics*2

Create a society where people's capabilities are maximized, through the application of mechatronics technology to medical/welfare segment.

*1 "Waku-Waku": Onomatopoeia used in Japanese language to express someone's feeling of enthusiasm

*2 Humatronics: Term coined to denote a cross of Human and Mechatronics

Features of Industrial Robot

- ◆ Tireless
- ◆ High Speed
- ◆ High Precision

Biomedical Field


Bio-analysis/ Drug discovery


Anticancer drug preparation

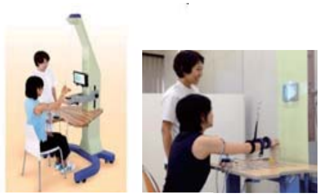
Excellent Reproducibility

Visualizing and Sharing of Skills

High Flexibility

AIST: National Institute of Advanced Industrial Science and Technology

Humatronics Domain


Upper Limb


Lower extremities


Walking Assist


ReWalk
(ReWalk Robotics)

Production System

- Mass Production

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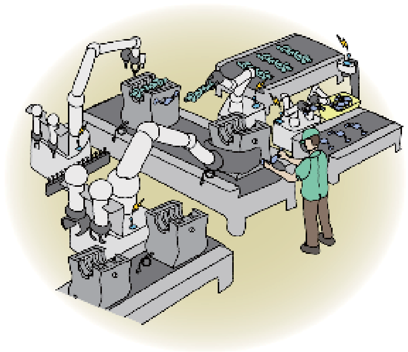
- Multiproduct Production
- Build To Order (BTO)

Cooperation with Human and Robots

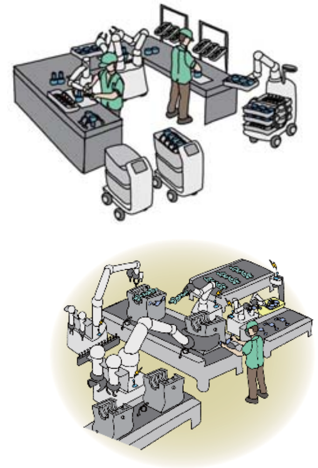
Cooperation with human



Cooperate with Robots

For Cooperation with Human and Robots

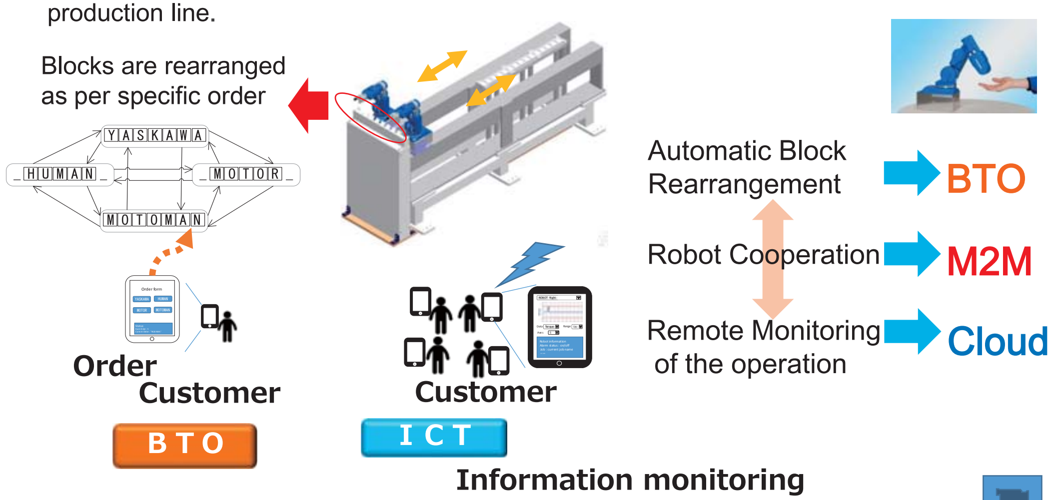
- Image Processing
- Error Recovery
- Motion Recognition
- Failure Prediction
- Task Planning
- Path Planning



Robotics for BTO manufacturing @ Hanover Messe 2015

Word Construction System

Robotics realizing Build-to-Order (BTO) manufacturing, and Remote Monitoring of the production line.



The Highlight of iREX2015

Are there any differences in each company's technology?

1. New Application
   - Assembly, …
2. Elemental Technology
   - Sensor (Vision, …)
   - Mechatronics (Components, Control)
3. Easy to Use
   - Teaching, Support Tools,…

Mr. Kazuhiko Yokoyama

General Manager of Tsukuba Research Laboratory
Corporate Research & Development Center
YASKAWA ELECTRIC CORPORATION

Biography:

Mr.Yokoyama is a General Manager of Tsukuba Laboratory, Yaskawa Electric Corporation.

He was received the M.S degrees in information engineering from Kyushu University, Fukuoka, Japan, in 1982.

After joining Yaskawa in 1982, he developed the system software of manufacturing industry robots.

Between 1989 and 2008, he was engaged in development of Non-manufacturing industry robots. Those are included the live line maintenance robot system, autonomous mobile robot “HelpMate”, Humanoid Robot “HRP” with AIST(National Institute of Advanced Industrial and Science Technology), Kawada Industries inc., and Simizu Corp and double 7 D.O.F (Degree Of Freedom) arm mobile robot “SmartPal”.

His research interest includes kinematics of robots and autonomous robots.

He is a member of the IEEE Robotics and Automation Society and a fellow member of the Robotics Society of Japan.