Document 7

Material of Lectures

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<Speaker of First Lecture>
Shigeo Hirose
CTO of HiBot Corp.,
Professor Emeritus of Tokyo Institute of Technology, and
Visiting Professor of Ritsumeikan University

Shigeo Hirose is a CTO of HiBot Corp., Professor Emeritus of Tokyo Institute of Technology, and Visiting Professor of Ritsumeikan University. He received Dr. E. degree in 1976 in Control Engineering from Tokyo Institute of Technology. His research interest is in the creative design of robotic mechanisms and their control. He was awarded more than 70 academic awards, including Joseph Engelberger Robotics (2009), Carlos Ghosn Award (2008), Medal with Purple Ribbon from Japanese government (2006), Award of Merits from IFToMM (2004), the first Pioneer in Robotics & Automation Award (1999). He is a Fellow of IEEE, JSME and RSJ.

ロボット創造学入門
Introduction of Robot Creation

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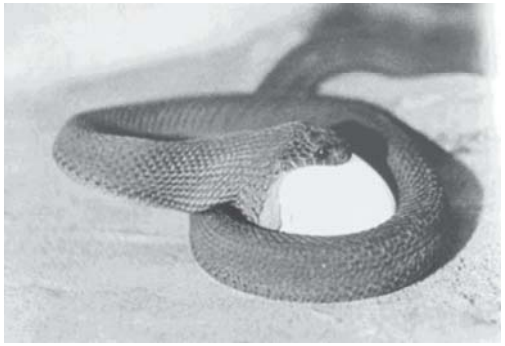
設計課題例
Example of Design Problem

お風呂に水が適量に溜まったときに、そのことを家人に知らせて水道の蛇口を止めに来るように知らせるアラーム装置を設計せよ.電気を使用する装置は使わないこと。

Design a bath alarm to notify that the bath water has reached the desired level and the faucet needs to be turned off. Electric instrument should not be used.

なぜへびなのか
Why snake?

足　Leg



手　Hand

手や足や胴体になる

It acts as leg, hand, and trunk

紐のような単純な形態ながら汎用的な機能を有する。
In spite of its simple shape, snake has versatile function.

↓

ヘビは新しい汎用型ロボットを開発するヒントを与えてくれる。
Snake is ideal source of inspiration for the design of new type of versatile robots!

ヘビ型ロボットの未来像
Snake-like robots can be:

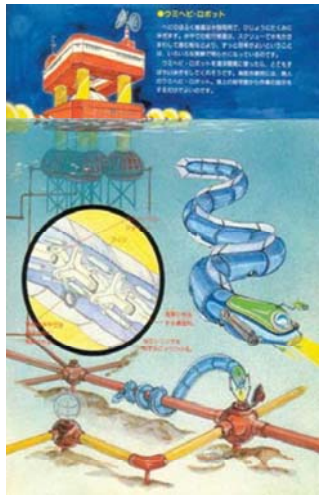
能動ロープ　Active Rope

能動内視鏡　Active Endoscope

極地探検車　Off-the-road Vehicle

ヘビ型ロボットの未来像
Snake-like robots can be:

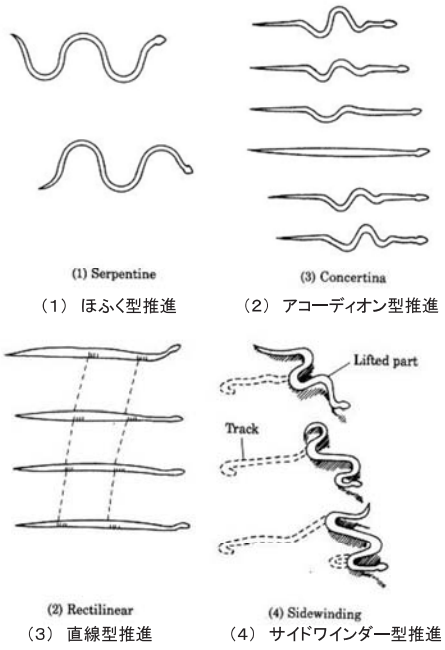
能動消防ホース　Active hose



水陸両用作業ロボット
Amphibious Vehicle

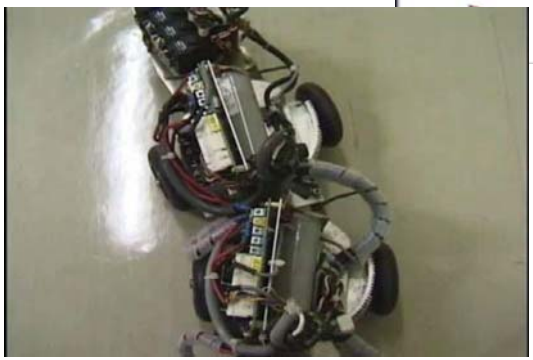
4種類のヘビ型滑走体型

Four types of the gliding motion of the snake



（1） ほふく型推進
（2） アコーディオン型推進
（3） 直線型推進
（4） サイドワインダー型推進

ACM III
私が1972年に作った世界最初のヘビ型ロボット
World-first snake-like robot I made in 1972



ACM R1
1990年代に改造したモデル
The model I made in 1990s

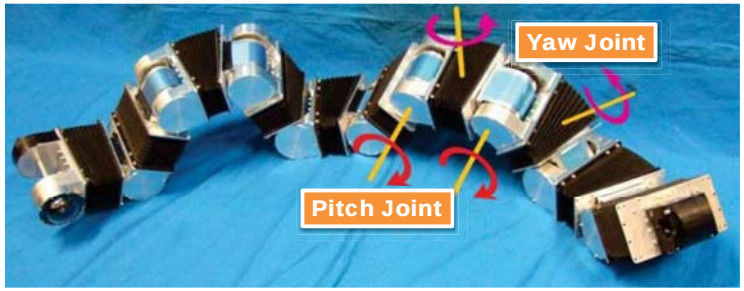
ACM-R3

運動自由度D.O.F.: 20
長さ Length: 1755[mm]
幅 Width: 110 [mm]
高さ Height: 110 [mm]
重さ Weight : 12.1[kg]

ACM R-5 2005

水陸両用ヘビ型ロボット Amphibious Snake-like Robot

ACM-R7 2010



サイズ Dimension :	1589×140×74 mm
重さ Weight :	11.7 kg
関節数 Number of Joint :	18
モータ Motor :	6W DC Motor × 18
バッテリー Battery :	7.2V-900mAh NiMH × 9
搭載計算機 CPU :	SH2 7047

ACM-R7

尺取虫移動

Pedal-Wave Gait

サイドワインダー移動

Side Winding Gait

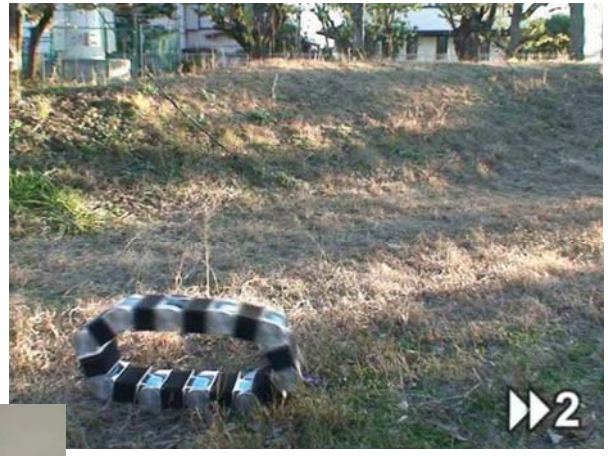
ACM-R7

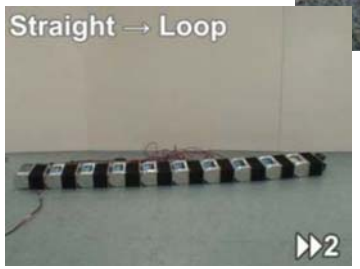
環状移動

Loop Gait

顎による連結

Connection by Jaw



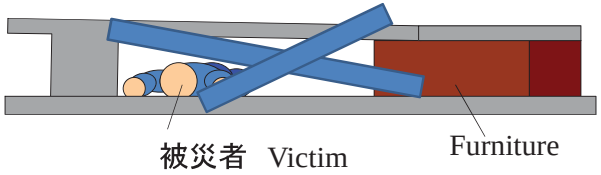


ロボットによる探査が必要な災害現場のアクセス部は狭い

Access to the victim at the disaster site is normally narrow

ヘビ型探査ロボットはこの用途に最適である

Snake-like rescue robot is ideal for this application



Souryu-III 蒼龍3号機

人力ヘビ車 Human-drive Snake-Vehicle

（2008 winter by students of Strathclyde students of Scotland）
（2008年 冬 スコットランドのストラスクライド大学の学生たちの作品）

江戸川河川敷で災害警備総合訓練　警察、消防など1200人参加 - 産経新聞（2012年7月5日18時35分）
Training of Tokyo Metropolitan Police against tero-attack

首都直下地震に備え、警視庁の災害警備総合訓練が5日、東京都江戸川区の江戸川河川敷で行われ、機動隊員ら約1200人が救助訓練などに取り組んだ。訓練は毎年行われているが、今回は初めて東京消防庁や陸上自衛隊、神奈川県警、海上保安庁も参加した。

津波を想定した訓練では、東京消防庁や陸自のヘリコプターから降下した隊員が、救出活動を実施。警視庁や神奈川県警、海上保安庁のボートが江戸川に出動し、漂流者を助けた。

倒壊建物の避難訓練には地元の区立篠崎第2小学校の児童70人も参加。化学工場爆発を想定した訓練では、東京工業大学開発のヘビ形ロボットで人の近づけない場所の生存者を捜したり、千葉大学開発の無人ヘリで捜索したりした。

蒼龍5号機　Souryu-V

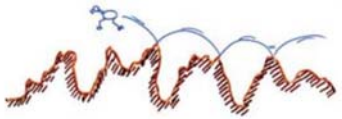
クモ

Spider

脚長クモ

Spider with long legs

Fig. A. Planned ambulating quadruped transporter

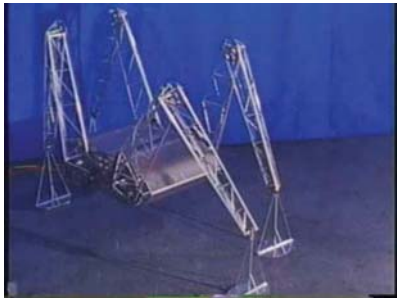


地上の約半分は在来の車両では近づくことができない。対地適応型の歩行ロボットはそのような環境に入り込むことができて人間の活動分野を大きく拡張する。

About half of the land on earth is said to be inaccessible by normal wheeled vehicle. Walking machine will greatly enlarge the area of human activities.

歩行ロボットの最適な足の本数
Optimum Leg Number of Walking Vehicle

•機構は単純で軽いほうが良い
Mechanism should be simple and lightweight
→足の本数は少ない程良い
Smaller the Better

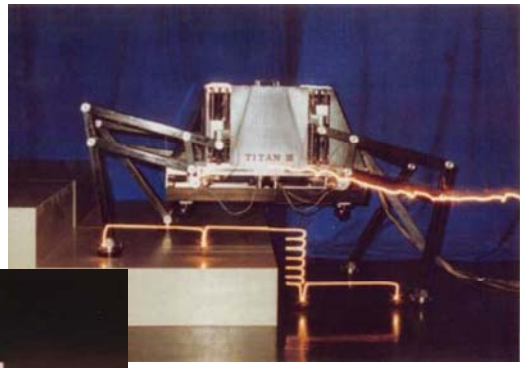


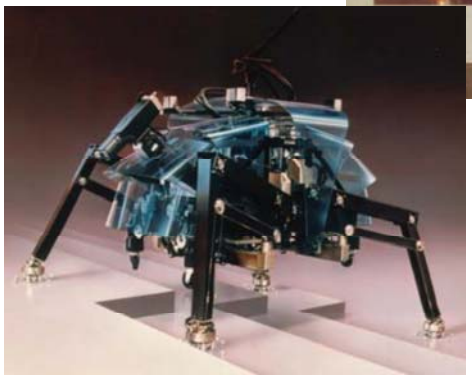
KUMOーI

•歩行時に静的安定性を確保したい
Capable of statically stable walk
→ 立っているときは3脚以上必要
More than three legs is needed to stand

4脚歩行ロボットが最適
Quadruped is Best

TITAN III





TITAN IV

崖で行う土木作業を行う4足歩行ロボット

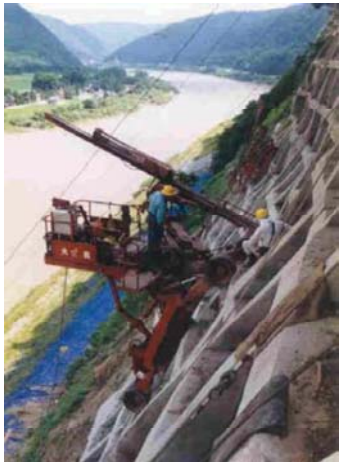
Quadruped Walking Robot for Steep Slope Construction Task

背景　Background

急な崖での土砂崩れ防止用補強作業
Reinforcement task on a steep slope to prevent landslide

以下の特性が必要
- 法面での全方向移動性
- コンクリートの枠を傷めない

It is needed to make
- Omni-directional locomotion
- Avoiding the damage of frame



第１次モデルによる７０度の斜面での歩行実験
Experiment with first model to walk on the slope of 70 degrees inclination

レーザーセンサを用いた地形適応型歩行の実験
Terrain adaptive walk of TITAN VII by using the laser range finder

ミラー追尾型３次元レーザーセンサの導入
Introduction of the mirror tracking 3D laser sensor

㈱トプコン製　トータルステーション
Total Station (TOPCON Co.)

性能　Feature of the TS

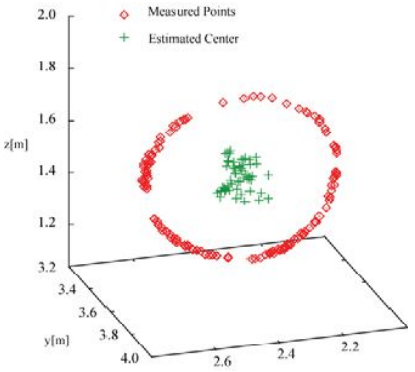
1. 計測範囲　2km以上
   Measuring range: more than 2 km.
2. 計測精度　1km離れた地点で4ー5mm
   Accuracy: ±4-5 mm in x,y,z directions at 1000 m away
3. 自動追尾性能：コーナーキューブ鏡を自動追尾可能
   Automatic motion: automatic searching of the corner cube.

崖の3次元地図の作成
Map generation of the slope

最初に作業者が現場を点検するので、その際にコーナーキューブを格子点に置いて位置を計測し地図を作る
As the worker have to survey the site beforehand, we introduced the way to measure the site by placing the corner cube at the crossing points of the ferro-concrete frames.

作成された地図
Generated 3D map of the frame

ロボットに搭載する回転するコーナーキューブ鏡　ーこれによりロボットの位置と姿勢が計測できるー
Rotating corner cube on the robot to measure the position and orientation of the robot



TITAN11号機の対地適応型歩行
Terrain Adaptive Walking of the TITAN XI

TITAN11号機による削孔作業
Drilling Operation by the TITAN XI

南アルプスで行った現地実験の様子
Operation Experiment on the South Alps Site

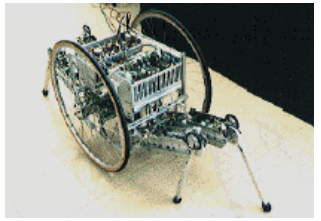
脚と車輪の複合

Combination of Leg and Wheel

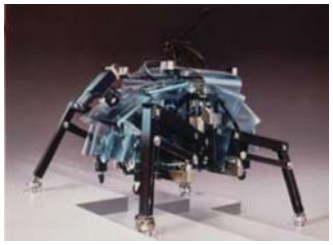
従来の脚車輪複合移動ロボット
Former examples of leg-and-wheel hybrid vehicles

Underground Excavating Machine
(Mechanical Engineering Laboratory, AIST, MITI)

Disaster-Prevention Robot (KOBE STEEL Ltd.)

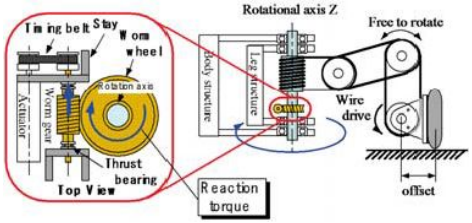


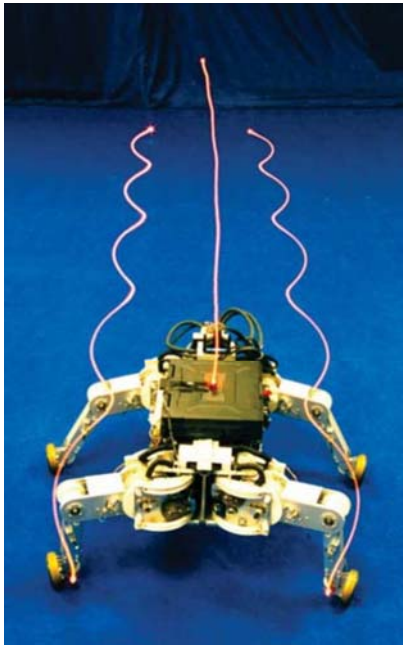
Chariot II (Tohoku University)



TITAN IV (Tokyo Institute of Technology)

ローラーウォーカー
Roller Walker



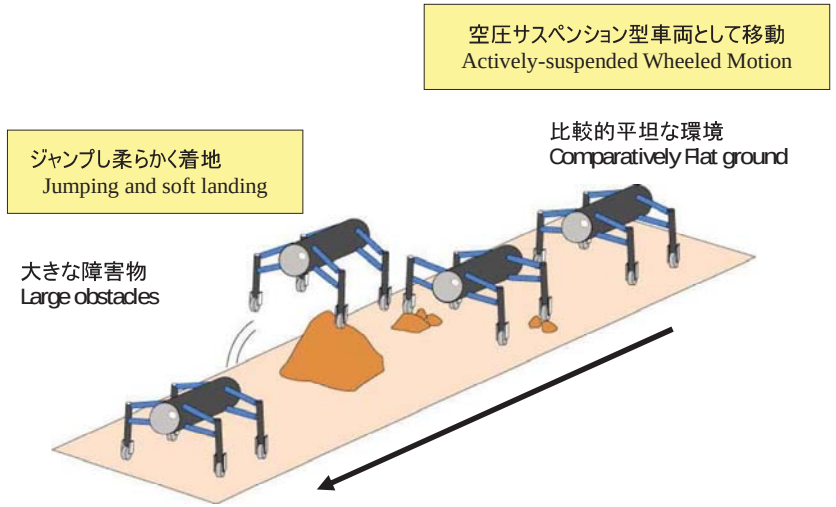


跳躍脚と車輪の複合

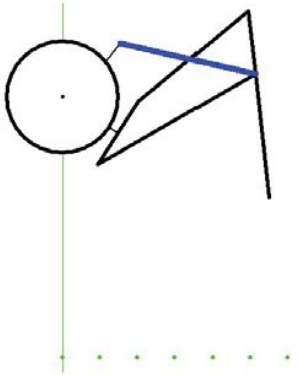
Combination of Jumping Leg and Wheel

飛べたらどうか　What if we can jump!

エアーホッパーの未来
Expected Motion of AirHopper



脚駆動機構
Leg driving mechanism



擬似的な直線軌道を生成する4節リンク型脚
4-bar-linkage mechanism to generate pseudo-linear movement

2つの空圧シリンダで動きを生成
2 parallel cylinders act as coupled drive large vertical force is obtained

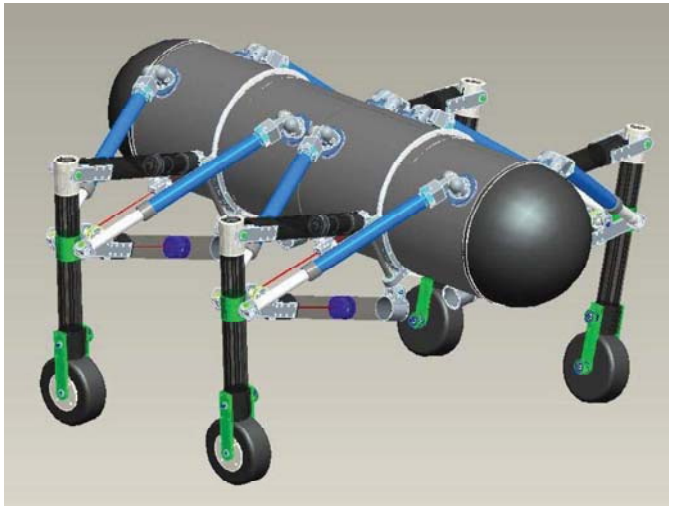
跳躍動作（車輪なし） Jumping of Air Hopper without Wheels

- 垂直跳躍距離 Vertical Jump 0.8m
- 水平ジャンプ距離 Forward Jump 1.3
- 衝撃吸収着地 Soft landing

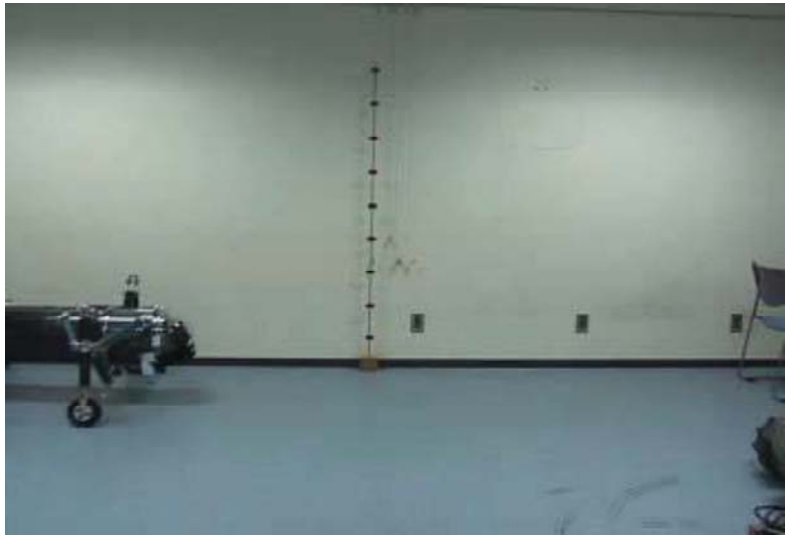
供給空気圧 Supplied Pressure：0.6[MPa]

長さ Length 1.3m
幅 Width 1.2m
高さ Height 0.5 m
質量 Mass 29 kg

車輪付きエアーホッパーとピストンワイヤー機構
AirHopper with Active Wheels and Piston-Wire Mechanism



開発途中のエアーホッパー
AirHopper On-going Research



よりいい動きを始めたエアーホッパー
AirHopper Getting Better

クローラ

Crawler

TAQT Carrier
(1991, with TAKAOKA Co.)

TAQT Carrier

JCO原発関連事故の後に開発されたロボット　MARS
The robots developed as the reaction of JCO accident (2001)

Criticality Accident at the Uranium Conversion Facility occurred on September 30, 1999 in JCO Co.Ltd.

Mitsubishi Heavy Industry designed manufactured MARS, where two of my patents used for the HELIOS were licensed.

脚とクローラの複合

Combination of Leg and Crawler

HELIOS VII

HELIOS VII

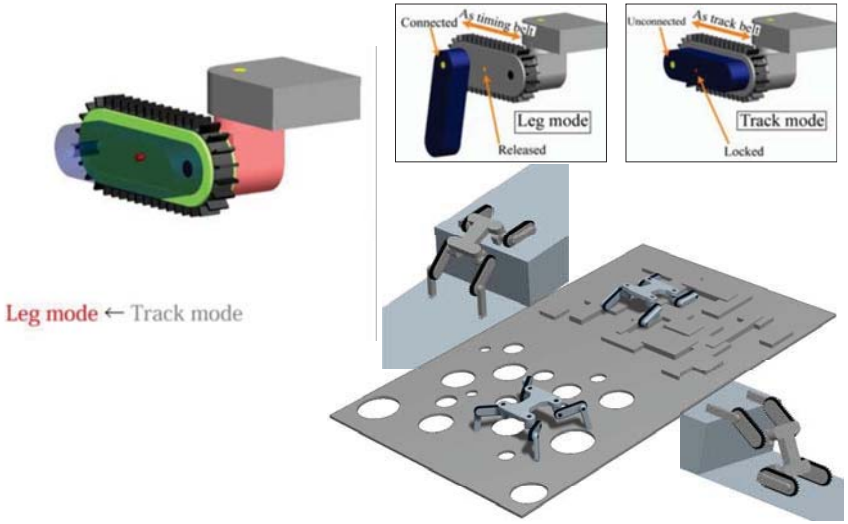
HELIOS IX

サーベイランナー Survey Runner
トピー工業 Toppy Industry

全長 Length 505㎜ 幅 Width 510㎜
質量 Mass 45kg 速度 Speed 2km/hr
連続運転 Continous Operation time 5hr
（濡れた）45度階段 235㎜段差 走破可能
Possible to climb 45 degrees wet stairs, across 235 mm step

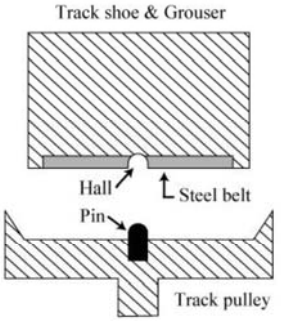
2012年度開発中の原発探査用ロボット
2012 Development of the Search Robot at Nuclear Power Plant

TITAN X: 脚クローラ複合ロボット
Leg and crawler hybrid robot



クローラベルト
Crawler belt

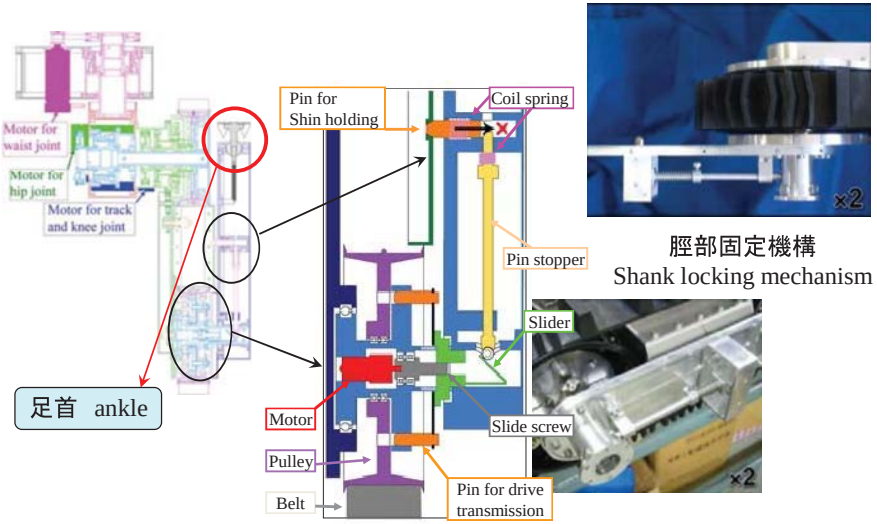
トピー工業との共同開発
Product of joint development with TOPPY Co.



軽量で強力
Lightweight and high load supporting belt

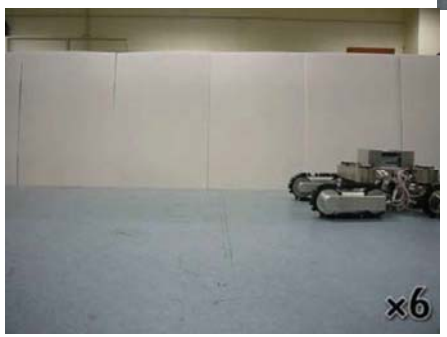
クローラとしてもまた動力を伝達するタイミングベルトとしても使える
It can be use as crawler and at the same time it can be used as torque transmission member

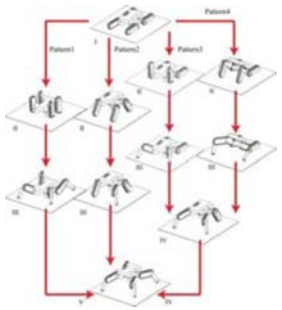
脚の固定機構　Locking Mechanism of the leg



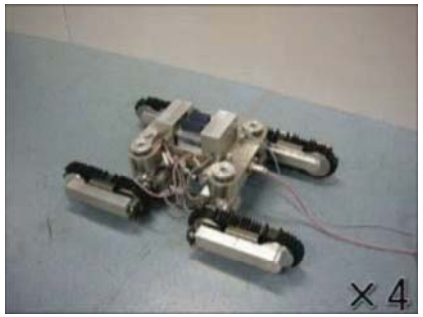
脛部固定機構
Shank locking mechanism

クローラ・脚変換動作
Transition between Crawler Mode to Walking Mode

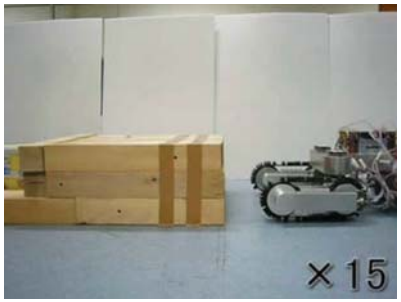




クローラ動作
Crawler Motion



大型障害乗り越え動作
Large Obstacle Crossing



300mm

従来にない形のロボット

Unconventional Shape Robots

高圧電線の点検用ロボット

Inspection Robot
for
High-Voltage Transmission Lines

Preventive maintenance of transmission lines

Problems:

-Pylons usually locate in remote, difficult to reach areas

-workers must walk on lines, tens of meters above ground

-power transmission must be interrupted during inspection

Main limitations of previous works: (SENSING)

- Inspection sensors far from cables, provide only partial data

- Dangerous to fly close to power lines

R. Ishino and F. Tsutsumi, "Detection System of Damaged Cables Using Video Obtained from an Aerial Inspection of Transmission Lines", IEEE Power Engineering Society General Meeting, 2, 2004, pp. 1857-1862.

I. Golightly and D. Jones, "Visual control of an unmanned aerial vehicle for power line inspection", Proc. IEEE Int'l Conference on Advanced Robotics, 2005, pp. 288-295.

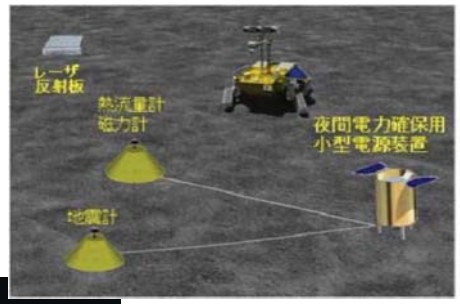
Expliner High voltage lines inspection robot

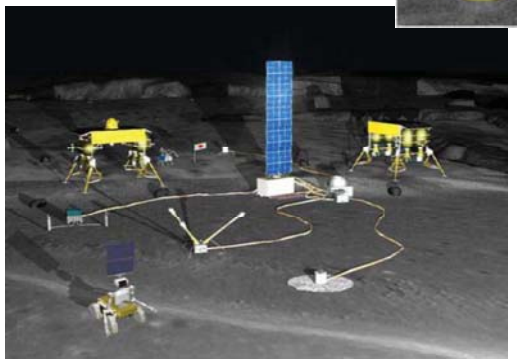
宇宙開発用惑星探査ローバー

Rover for Space Exploration

2025年に日本で打ち上げ予定の月面探査用ロボットの構想。南極付近に着陸し学術的に興味のある岩石を採取する

Concept of the Moon Robots of 2025 to survey interesting rock samples at the South Pole of the moon

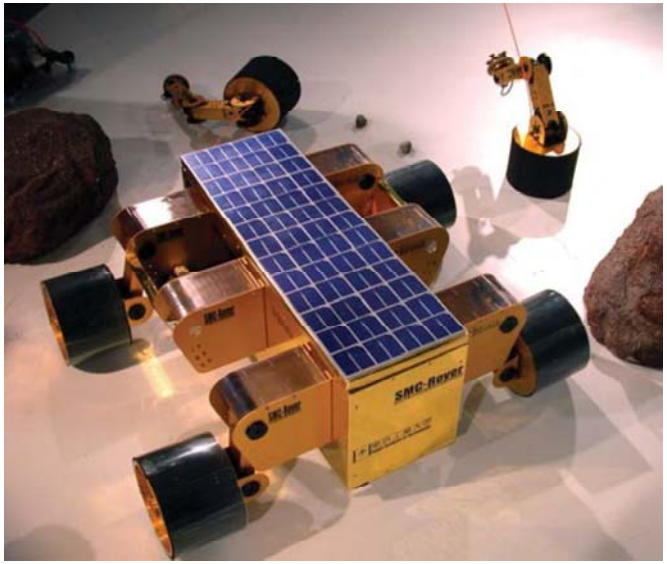


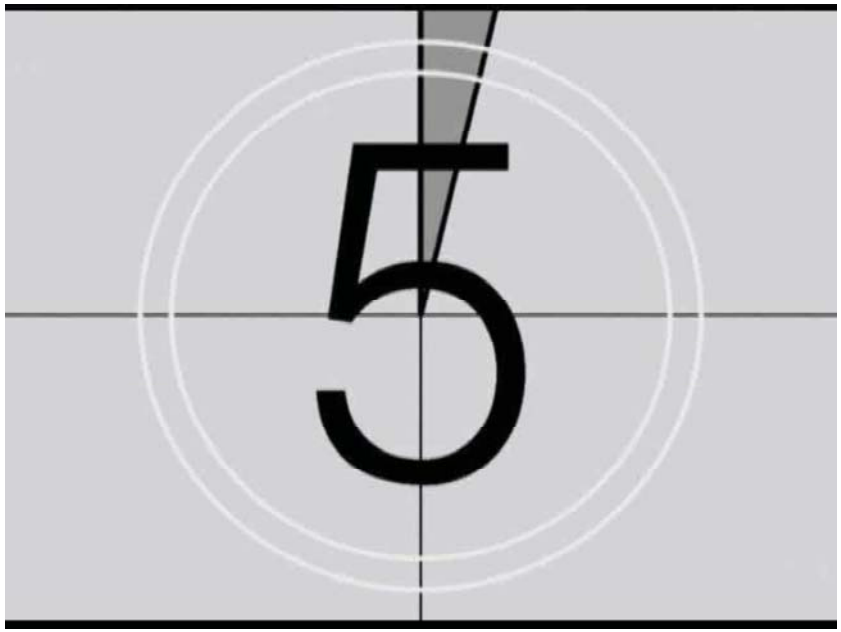


Tri-Star IV

Swarm

SMC Rover





ロボット創造　Robot Creation

ロボット研究開発者になるには
How to become the robot engineer

- エンジニアリングセンスを持とう
  Let us acquire the engineering sense
  - 機械がなぜ動くのか観察し考えよう
    Let us observe and understand the motion of machines.
  - 分解できるものは分解してみよう
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  - いろいろなロボット競技会に参加してロボット作りを楽しもう
    Let us attend some kind of robot contest and enjoy to make robots
- 創造的思考法を身に付けよう
  Let us educate ourselves to have creative thinking
- 基礎学力をつけよう
  Let us cultivate the basic academic background
  - 数学、物理学その他　Mathematics and Physics
  - 一般常識　common sense
  - 語学　English

日本機械学会主催　ロボットグランプリ
Robot Grand Prix

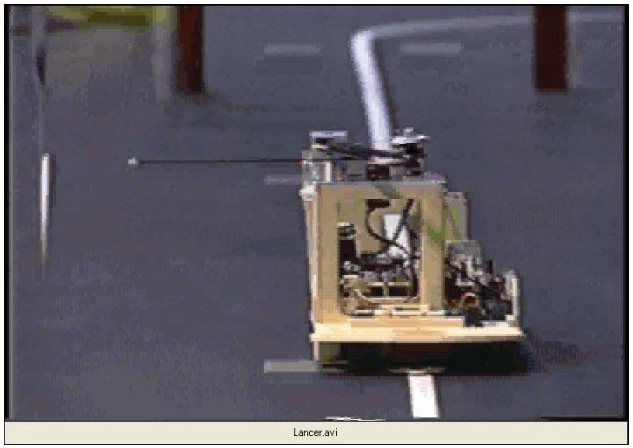
Science Museum at Kudan－sita
Mrach 22, 23

2014年3月22、23日(土曜、日曜)
九段下　科学技術館

スカベンジャー競技
Scavenger Robot Contest

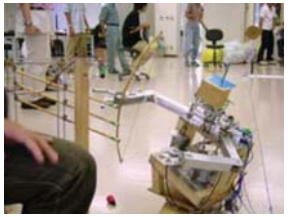
大道芸ロボット競技
Street Artist Robot Contest

ランサーロボット競技
Lancer Robot Contest



東工大　4類　機械宇宙学科
3年生　機械創造

Robot Creation course
Tokyo Tech Department of
Mechanical and Aersopace Eng.



回答②

【回答】

図１に装置全体図を示す。装置は、ゲート（浮きと一体化されている）、ケース、球、ロープ、滑車1、滑車2、木槌、板から構成されている。

ケースはある特定の場所に固定されている。１箇所だけ側面が開放されており、下面はその開放面に向かって傾斜している。ケースには、ゲートが図の上下方向にスライド可能となるように取り付けられている。また、ケースとゲートで仕切られた空間に、球が置かれている。（図２参照）

ゲートには浮きが一体化されており、お風呂に水が溜まり、水が浮きに接した段階で、浮きに浮力を与える。その浮力によりゲートが上方に押し上げられる。ゲートが上方に押し上げられる事で、球は斜面を滑り、ケースから落下する。（図３参照）

球はロープ結ばれており（剣玉の球のように）、そのロープはもう一端を滑車に取り付けられている。球が落下する事で、ロープが引っ張られ、滑車２が図の時計回りに回転する。

滑車２には、木槌が固定されており、滑車２が回転すると同時に木槌も回転し、その木槌が板を叩くことで音が鳴る。板は、上部のみ固定されているため、木槌の回転を停止させる事は無い。

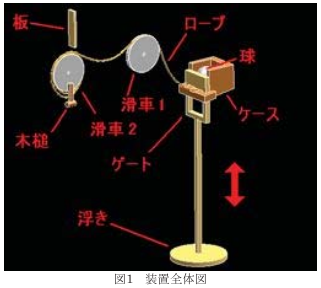


図1　装置全体図

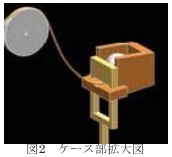


図2　ケース部拡大図

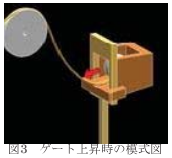


図3　ゲート上昇時の模式図

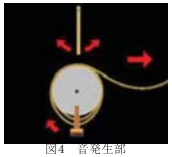
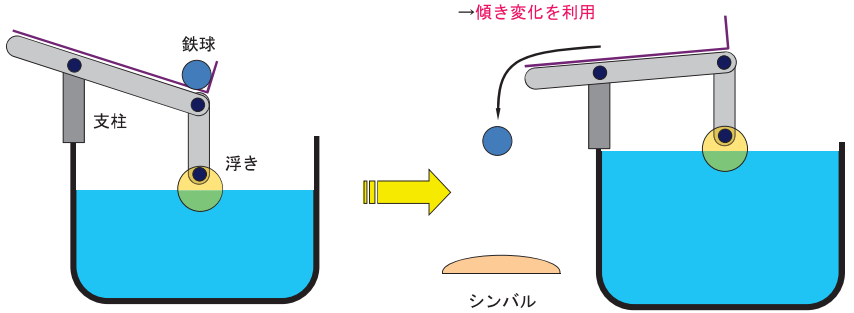


図4　音発生部

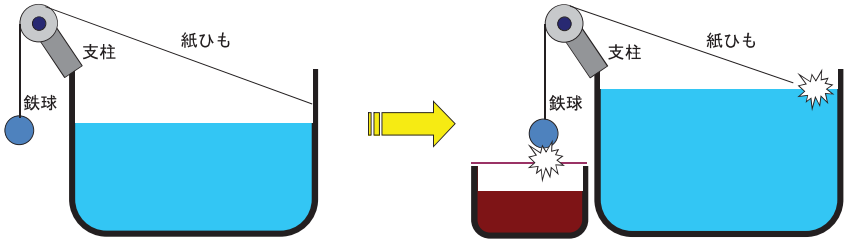
回答③−1



他
太鼓、鉄琴…楽器
寝ている子供…動物

→音で知らせる

回答③−2



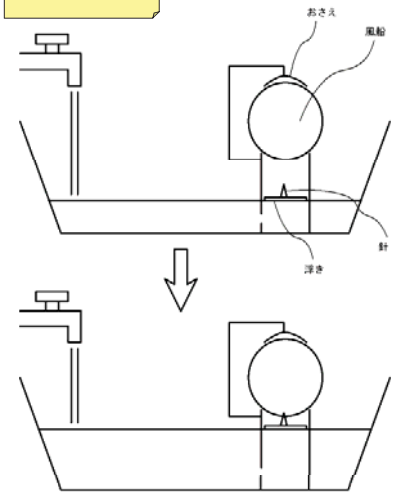
→濡れによる劣化を利用

薄紙で蓋した糠床

他
　くさや、納豆…

→臭いで知らせる

回答④



- 左図のように風呂に中空のシリンダを置き、さらに風船を置く
- シリンダ内には針を備えた浮きを入れる
- 水位が上がると浮きが上昇し、所望の水位で針が風船を刺し、破裂音で知らせる
- おさえは針から風船が逃げないため

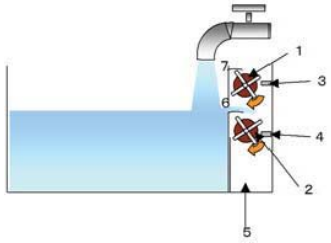
回答⑧

- 水位が6の高さまでなると排水口6から水が溢れ出す。溢れ出した水は回転体2を回す事となる。
（水車のような原理）回転体2に取り付けてある棒状のものが4に接触する事により音（警報音）を発する。4を2の回転を妨げない程度の弾性体とする事により、2は回り続け、音（警報音）は鳴り続ける。これにより音（警報音）の聞き逃しをある程度防止できる。
2に鈴のようなものを付けておくのも良いかもしれない。

排水口7から水が溢れ出しても上記と同じように1、3により音（警報音）が鳴る。

排水口と回転体（例えば2）を複数持っていなくても、
排水口と回転体（例えば2）を上下移動可能にすれば様々な水位に対応可能となる。

また、話はずれるが容器5を設けておくことにより、溢れ出してしまった水を溜めることが可能となる。
これにより水の無駄を防げる（溜まった水の再利用可）。
また、水の落下により得られた力をギヤを介して蛇口に伝導できれば自動で水を止められるかもしれない。



回答⑨

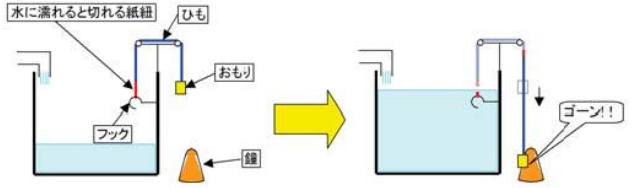
おもりと鐘を利用したアラーム装置

概要　おもりの重力と鐘の衝突によって音（アラーム）を出す。

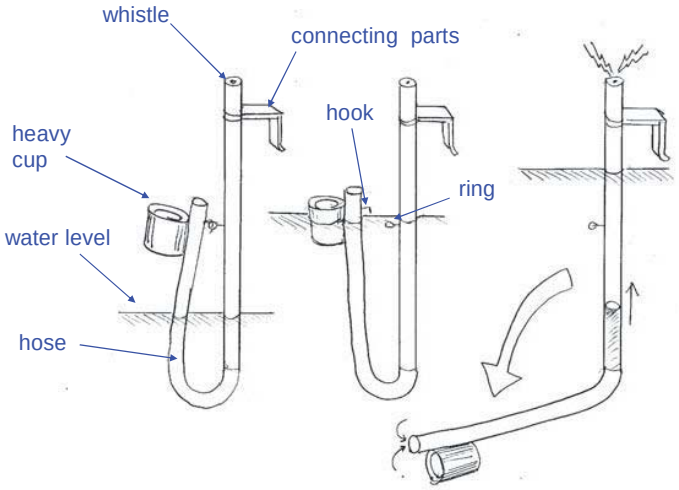
お風呂に図のような装置を設置。紐の片方にはおもり、もう片方には水に濡れると切れる紙紐（水溶性の紙紐）を設置し、フックないしは浴槽の内側に取り付ける。

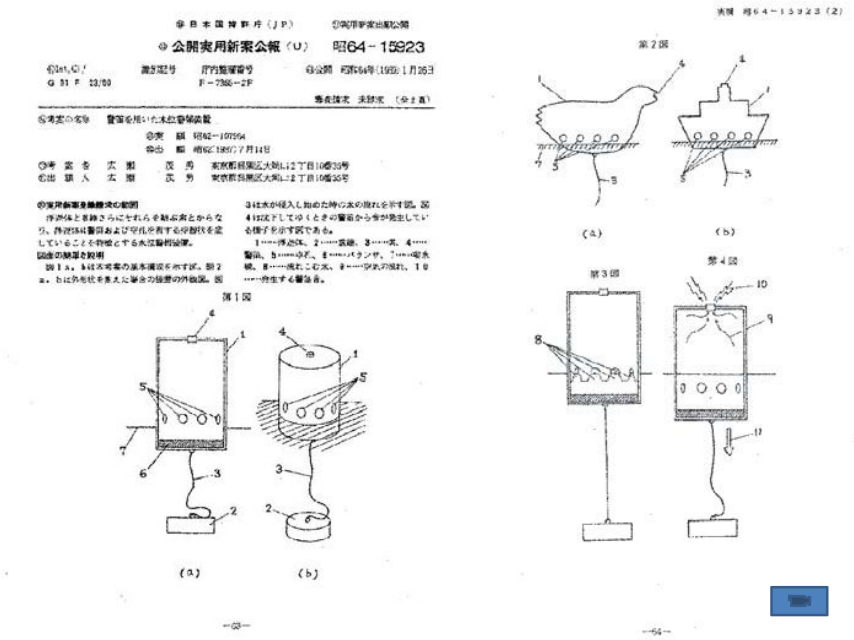
お風呂にお湯がたまっていったときに規定の量に達すると、紙紐が解けてきれ滑車を介してつながっているおもりが重力によって落下しかねに衝突する。

そのとき衝突により音が発生しお湯の水位を知らせる事ができる装置



An idea of my high school days





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  - 語学　English

結論 Conclusion

- ロボットの開発研究は面白い！！

Robot development is extremely interesting.

- 未来社会ではすべての機械がロボットになっていくためこれからロボット工学はとても重要である。

All of the machine will be evolved as robot in future, so it is very important to study about robotics.

- 役に立つロボット創造で社会に貢献しよう。

Let us contribute to the society by the robot creation.

<Speaker of Second Lecture>
NODA Akio
Mitsubishi Electric Corporation
Advanced Technology R&D Center
Head Researcher
(Amagasaki, Hyogo, JAPAN)

- In the Company
  - Engaged in research and development and its business promotion of intelligent technology of mechanical system, such as Industrial Robot, FA processing equipment, and Manufacturing Information System Integration.
- Outside (Academic Society and Education)
  - Director and Committee of Robotic Society of Japan, The institute of Systems Control and Information engineers, The Japan Society of Mechanical Engineers, and The Society of Instrument and Control Engineers.
  - Part-time lecturer at Some University.
- Outside (National Organizations and Industrial Associations)
  - Committee of METI, NEDO, COCN, JARA, and MSTC.

International Robot High School
インターナショナル・ロボット・ハイスクール

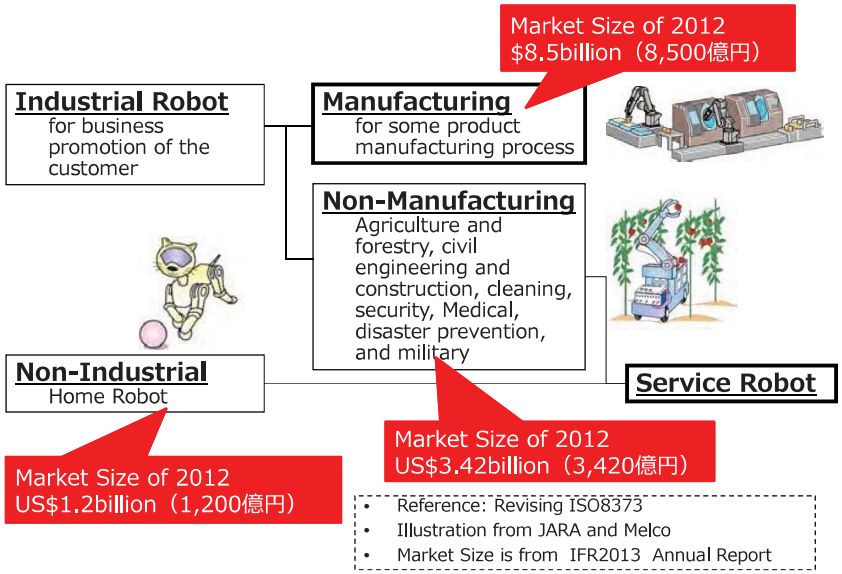
An ABCs of Robot
ロボットのイロハ

7th, Nov, 2013 @iREX2013
2013年11月07日　国際ロボット展

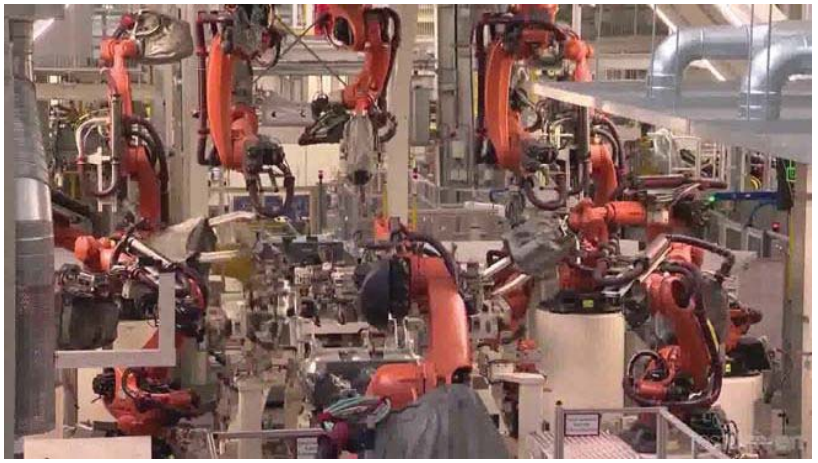
Timetable from now

11:10～12:40	**ABCs of Robot (90min)**
11:10～12:20	Lecture (70min)
	"Daily in Robot Manufacturer"
12:20～12:40	Task description(20min)
12:40～13:30	**Luncheon**
13:30～17:00	**Investigation in the exhibition halls**
17:00	**Gathering and Dissolution**

Classification of Robots



Manufacturing Robots?

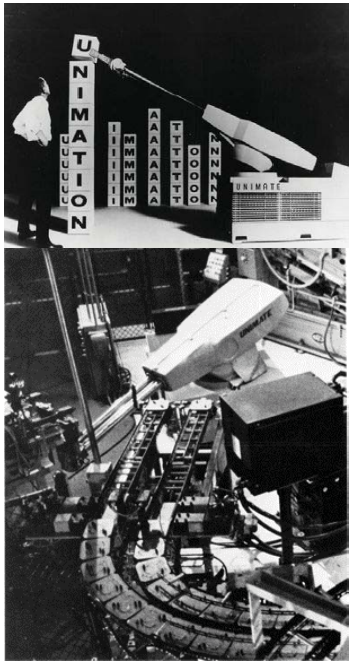


(YouTube - VW Golf 7 Produktion Wolfsburg 2013 [HD] [Volkswagen Golf Mk より)

The Dawn of Manu. Robots

1954	Devol's Patent "Programmed Article Transfer"
1958	Consolidated Control Co. Trial Machine "Automated Control Apparatus"
1962	Unimation Co.(Dr. Engelberger)"Unimate" AMF Co. "Versatran"
1969	Kawasaki Heavy Ind. Co. "Unimate 2000"
1970	1st Intl. Symposium on Industrial Robots
1973	Japan Industrial Robot Association Established
1974	1st Intl. Robot Exhibition
	ASEA Co. (Now ABB) "Electric MultiJoint"
1975	Olivetti Co. "SIGMA"
1978	Prof. Makino "SCARA"
1978	Unimation Co. "PUMA"
1980	Robot spread first year

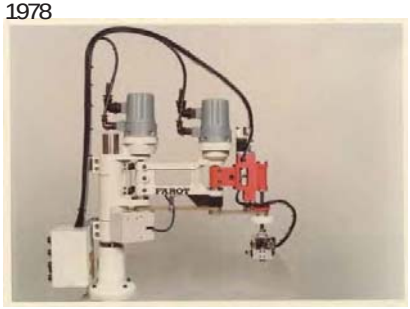
(By Courtesy of RSJ, http://www.prsrobots.com)



1969

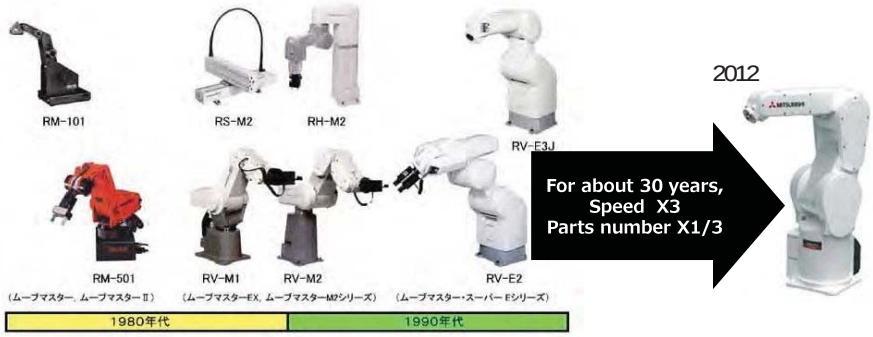
1977

1978



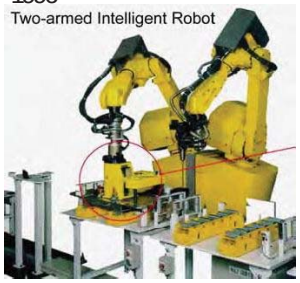
1983

(By Courtesy of RSJ, Wikipedia)

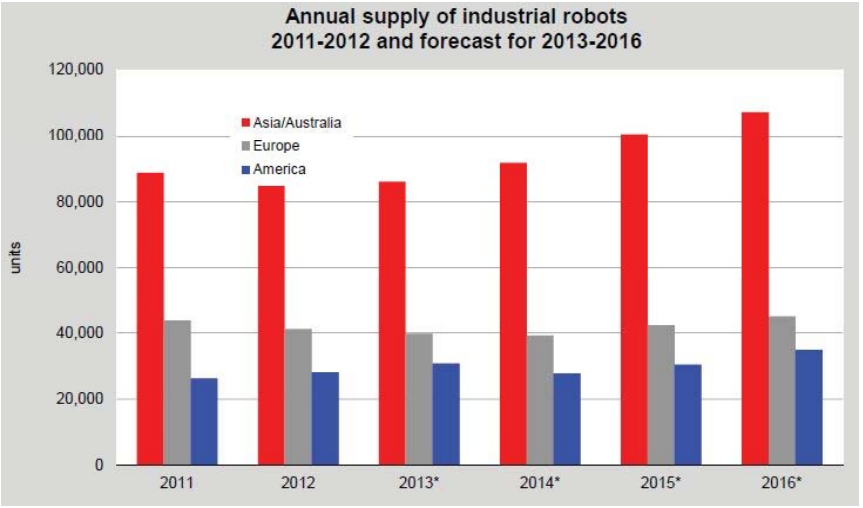


Restructuring of the industry also progressed:
282 companies at 1985
85 companies at 2012

1996
Two-armed Intelligent Robot



(By Courtesy of RSJ, Mitsubishi Electric.)



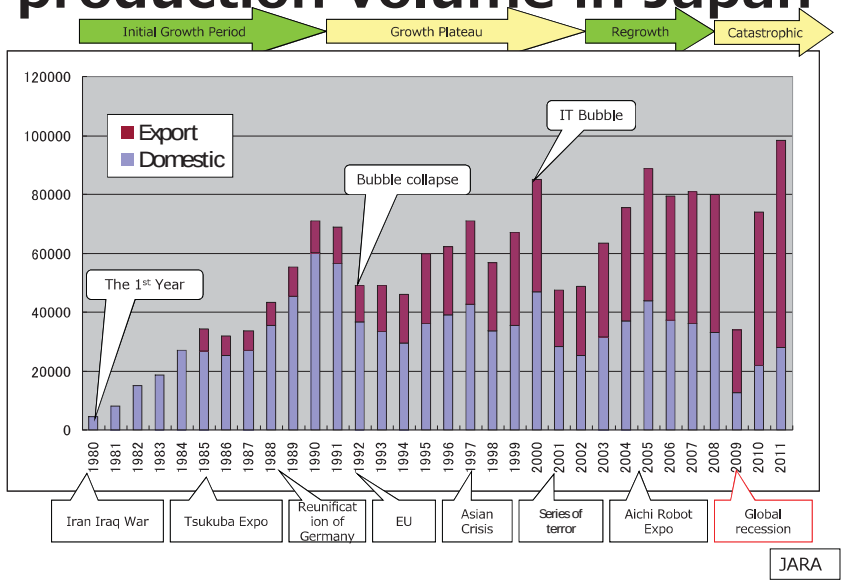
(from IFR2013 annual report)

Estimated yearly shipments of multipurpose industrial robots in selected countries. Number of units

Country	2011	2012	2013*	2016*
America	**26,227**	**28,137**	**30,800**	**34,900**
Brazil	1,440	1,645	2,000	3,500
North America (Canada, Mexico, USA)	24,341	26,269	28,500	31,000
Other America	446	223	300	400
Asia/Australia	**88,698**	**84,645**	**86,000**	**107,200**
China	22,577	22,987	25,000	38,000
India	1,547	1,508	1,500	3,000
Japan	27,894	28,680	27,200	32,000
Republic of Korea	25,536	19,424	20,500	19,500
Taiwan	3,688	3,368	4,000	4,500
Thailand	3,453	4,028	3,500	5,000
other Asia/Australia	4,003	4,650	4,300	5,200
Europe	**43,826**	**41,218**	**39,800**	**45,000**
Czech Rep.	1,618	1,040	1,000	1,500
France	3,058	2,956	2,900	3,200
Germany	19,533	17,528	16,500	18,000
Italy	5,091	4,402	4,200	4,500
Spain	3,091	2,005	2,000	2,500
United Kingdom	1,514	2,943	2,000	2,600
other Europe	9,921	10,344	11,200	12,700
Africa	**323**	**393**	**500**	**700**
not specified by countries**	6,954	4,953	4,900	4,000
Total	**166,028**	**159,346**	**162,000**	**191,800**

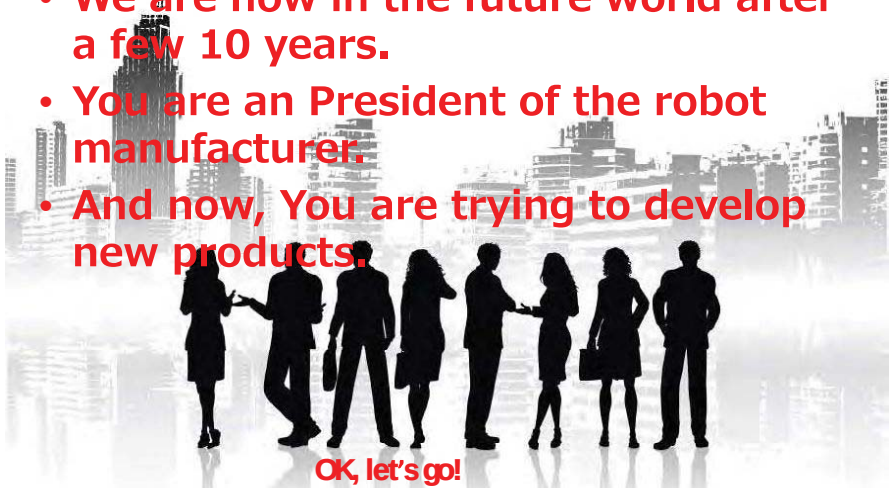
(from IFR2013 annual report)

Manufacturing robot production volume in Japan



Now, close your eyes, please imagine

- **We are now in the future world after a few 10 years.**
- **You are an President of the robot manufacturer.**
- **And now, You are trying to develop new products.**

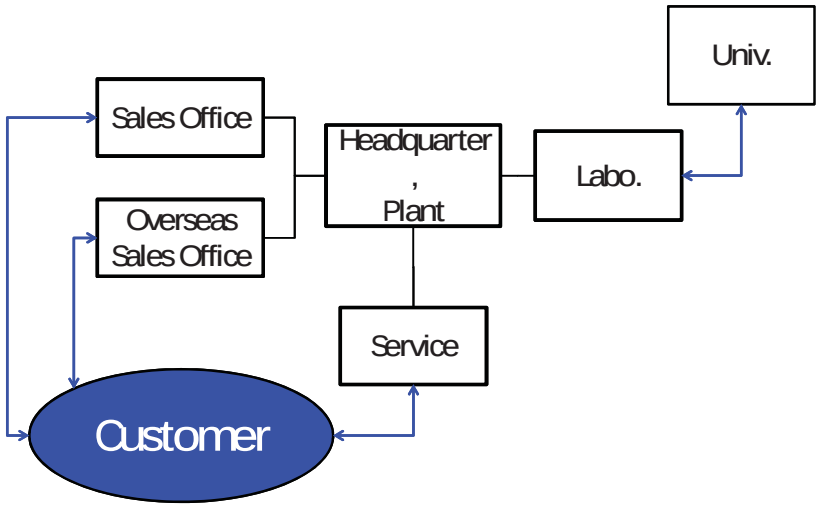


①Your Company has,

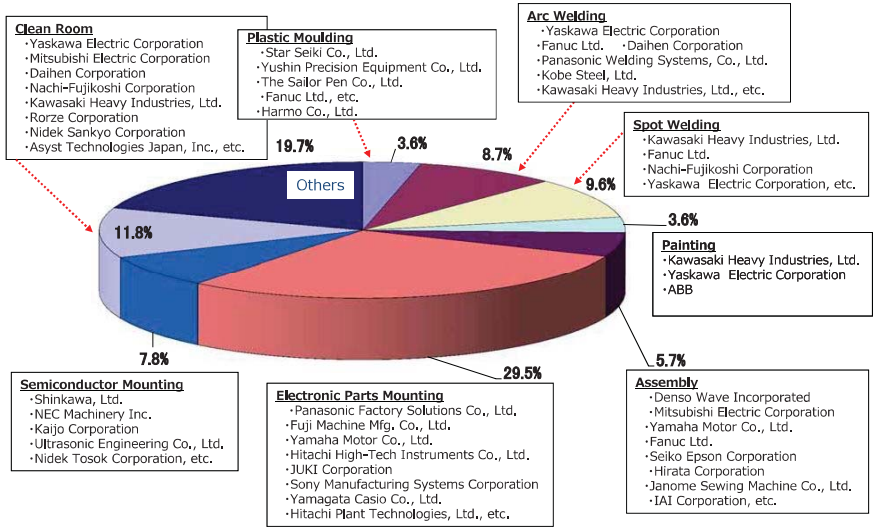
- Scale of Operation
  - 230 employees
  - US$0.1billion (100億円) in annual sales

  cf. The Japanese robot industry has, 7,000 total number of employees, about US$3billion(約3,000億円) total annual production.
  (By JARA statistics)
- Business Facility
  - Laboratory: R&D, Univ. joint research
  - Plant: Headquarter, Development, Design, Quality Assurance, Manufacturing, Service
  - Sales Office: Domestic major regions
  - Overseas sales office: Europe (Eastern, Western, Africa), America(North, Latin), Asia(China, Korea, Taiwan, Singapore, India)

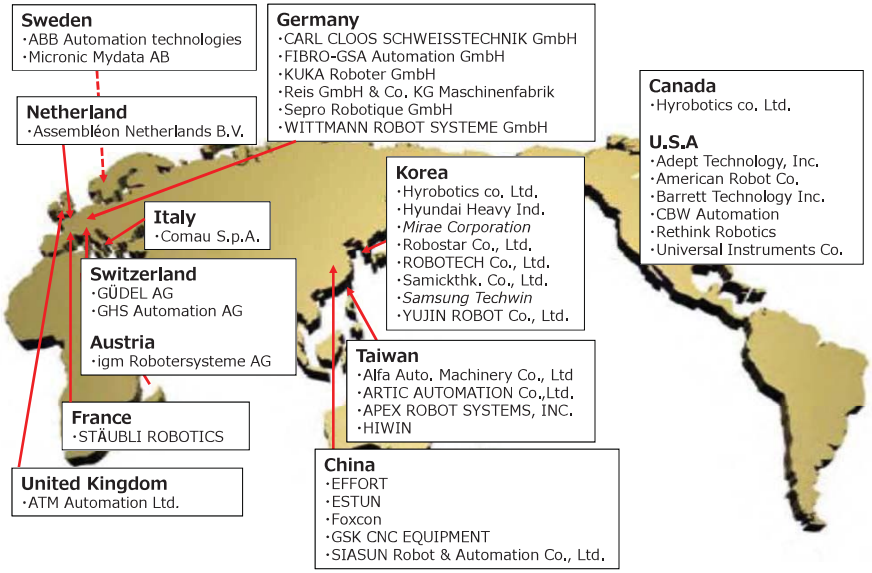
Organization chart of your company



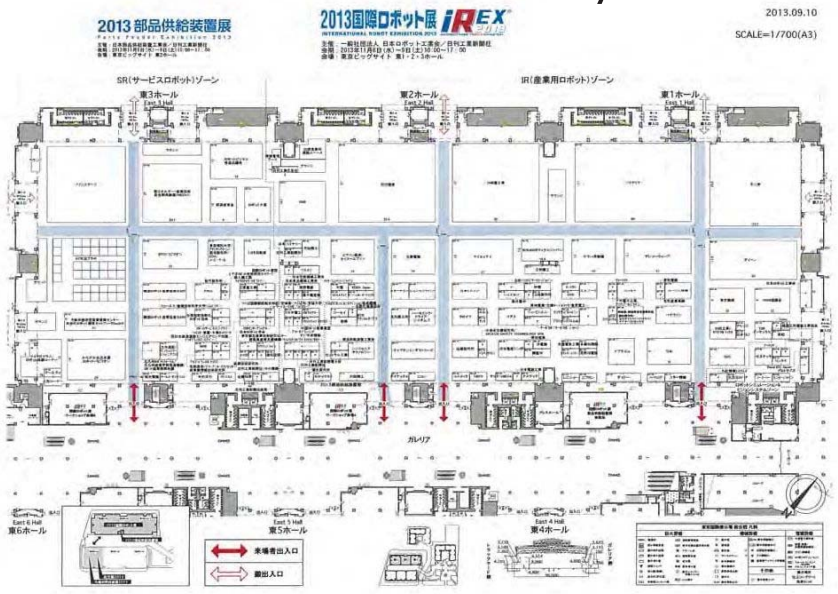
Shipping Percentages (2012) per Robot Applications and Main Manufacturers



Major industrial robot manufacturers in the world



iREX 2013 Hall Layout



②Medium-term Business Plan
(Market Analysis and How to Compete)

Create required products

Strengthening Basic Performance

Development Options such as Sensors

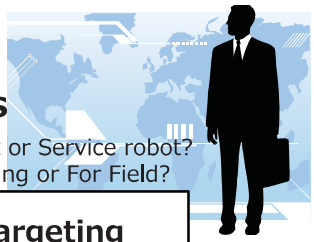
How to grow 10 percent of US$0.1 billion annually?

Increase the people who use our products

Sell to all over the world

Especially in Asia

③Product Planning
Marketing and Technologies



Industrial robot or Service robot?
For Manufacturing or For Field?

Market Trends

Nobel Production System is required.

Targeting
What do we aim?

Cost Requirements

Determination of product specifications

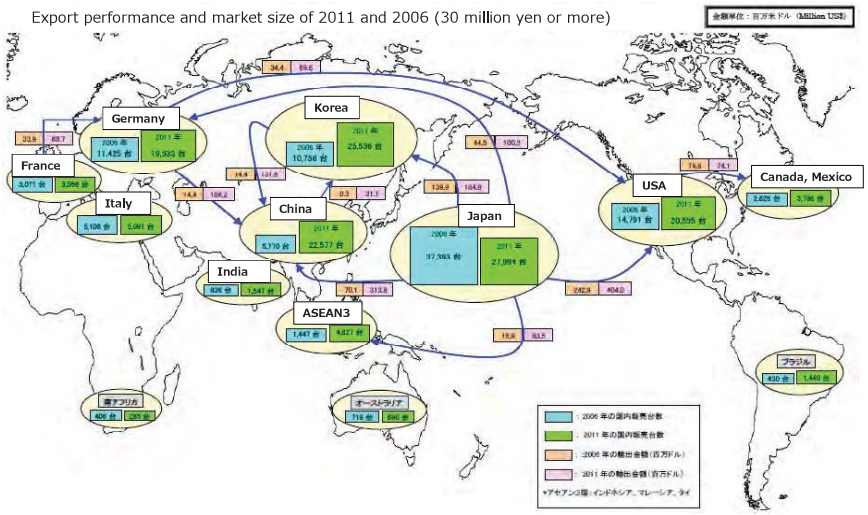
Load capacity 2Kg

Rivals
They do same thing!

Technologies

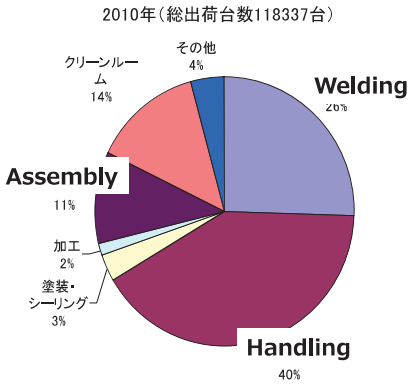
Manufacturing site and Shipping To

Export performance and market size of 2011 and 2006 (30 million yen or more)

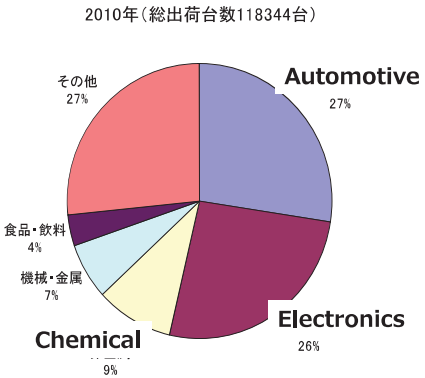


From METI Robot Industry Trends Survey 2012

Breakdown of worldwide shipments
(from IFR2011 Annual Report)



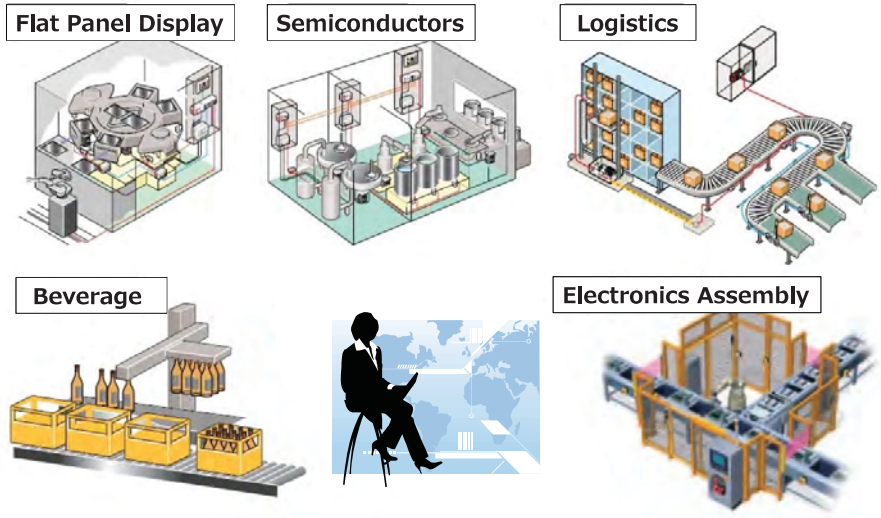
By Applications



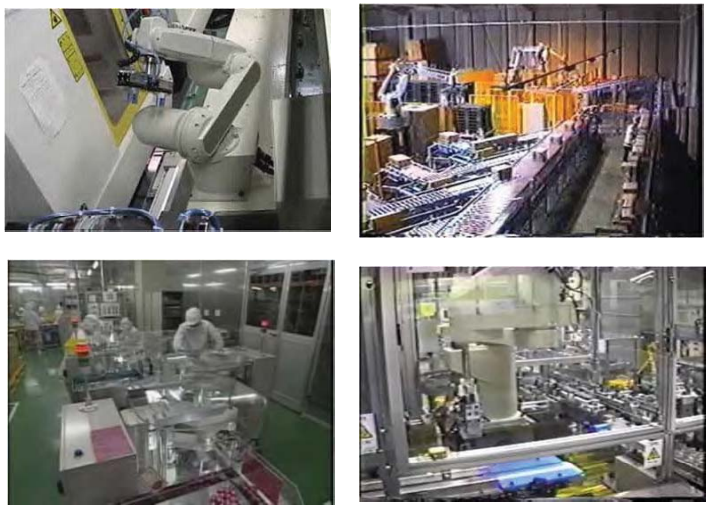
By Sectorial

Production System other than Automotive

(from Mitsubishi electric MELSEC Safety catalogue)



Robot working in various field



(By Courtesy of Mitsubishi Electric)

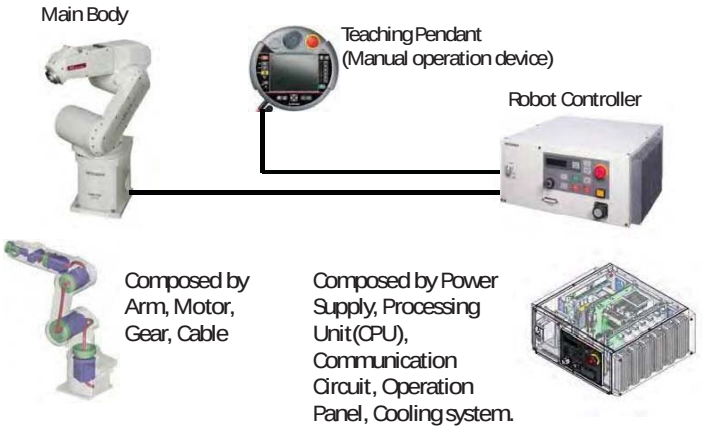
③Product Planning
Marketing and Technologies

- **Market Trends**
  - Export is Growing.
  - Non-Automotive application is increasing.
- **Segmentation and Targeting**
  - We aim to promote manufacturing industry in Japan for global competition.
  - robot for assembly of electrical and electronic industries (smart phone).
- **Main target specifications**
  - **Not for line production, but Cell manufacturing**
    →vision sensor and force sensor is requred
  - 1.5sec for Pick-and-Place (Simple human operation speed for one part)
  - Application: Connector insertion, Screwing, Polish, Key Touch Test
  - Capacity: 2Kg (Work is less than 150g, Hand is 1kg over)
  - Price: US$1.8mmilion (Decrease 3% of labor cost ratio)
  - 10 years life

④Development Desgin (Each Robot Technology)

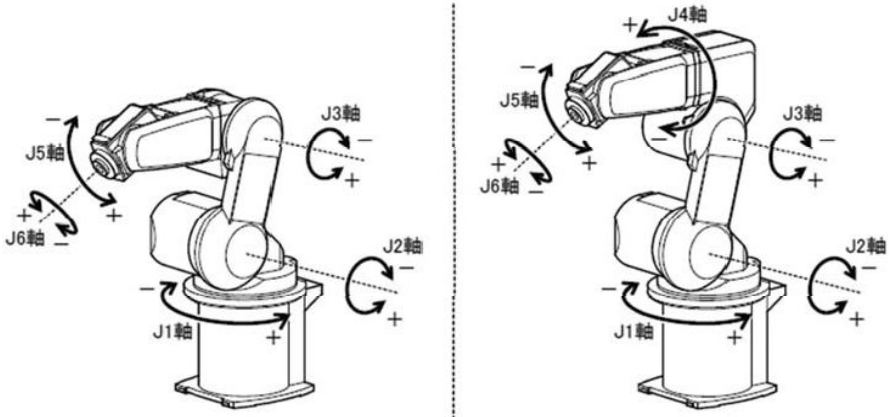
- Mechanism Type
- Vision Sensor
- Force Sensor
- Controller
- Teaching Pendant

Configuration of Robot



(By Courtesy of Mitsubishi Electric)

Robot Joint arrangement

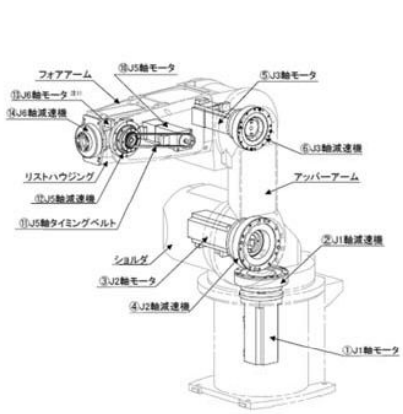


5-Axis vertical joint type

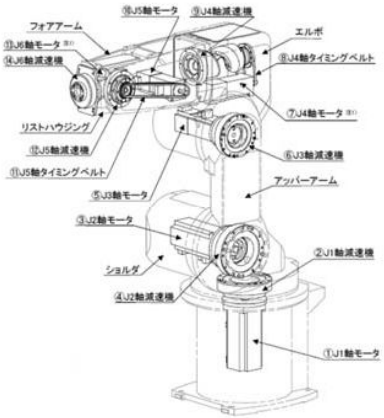
6-Axis vertical joint type

(By Courtesy of Mitsubishi Electric)

Inside of the body



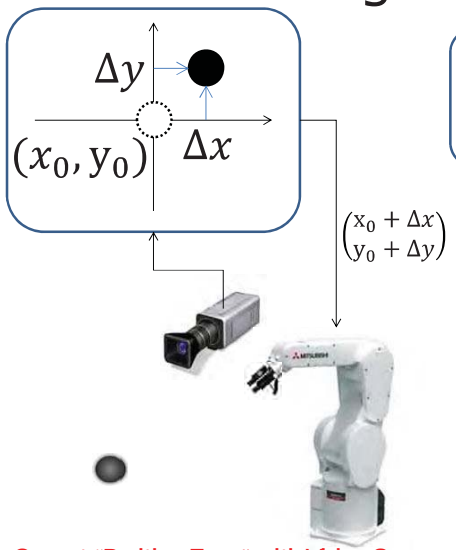
5-Axis vertical joint type



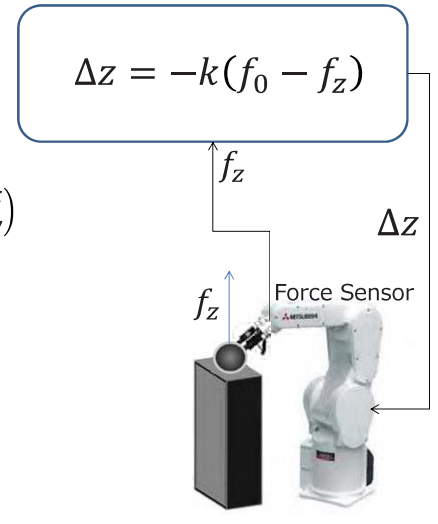
6-Axis vertical joint type

(By Courtesy of Mitsubishi Electric)

Using Sensors



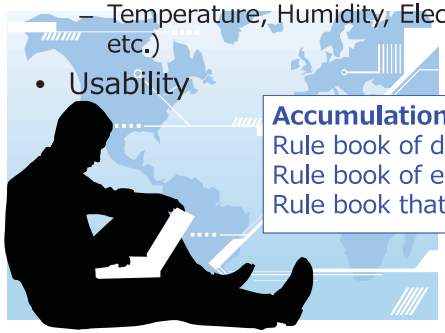
Correct "Position Error" with Vision Sensor



Adjust "Force" with Force Sensor

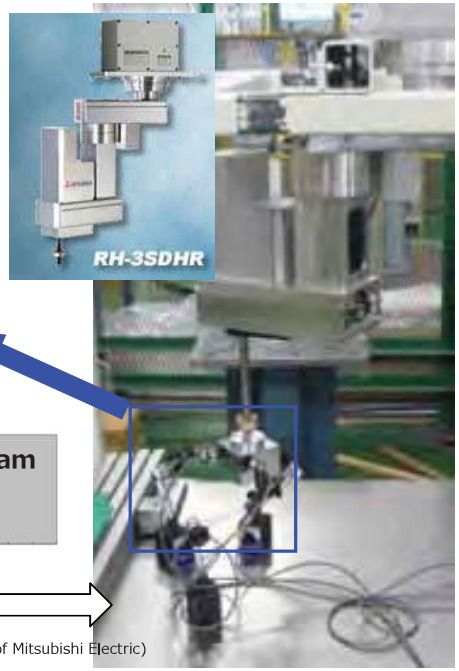
⑤Product Evaluation
(Variety of Evaluation)

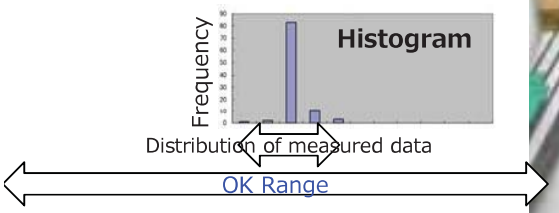
- Clear of basic specifications
  - Speed, Accuracy, etc.
- Life Test
  - Cable bending limit, Overload test, etc.
- Environmental Resistance Test
  - Temperature, Humidity, Electromagnetic Waves, Atmosphere, etc.)
- Usability



Accumulation of Value as a manufacturer
Rule book of design process
Rule book of evaluation method
Rule book that manages the development

Accuracy



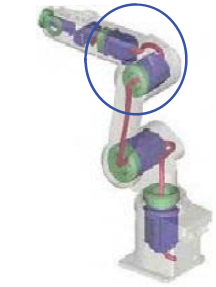


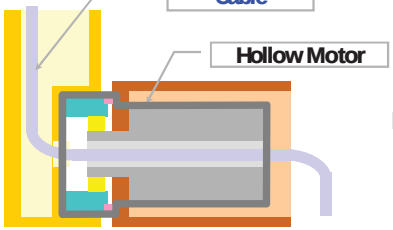
(By Courtesy of Mitsubishi Electric)

Speed

(By Courtesy of Mitsubishi Electric)

Endurance Test Example (Cable)

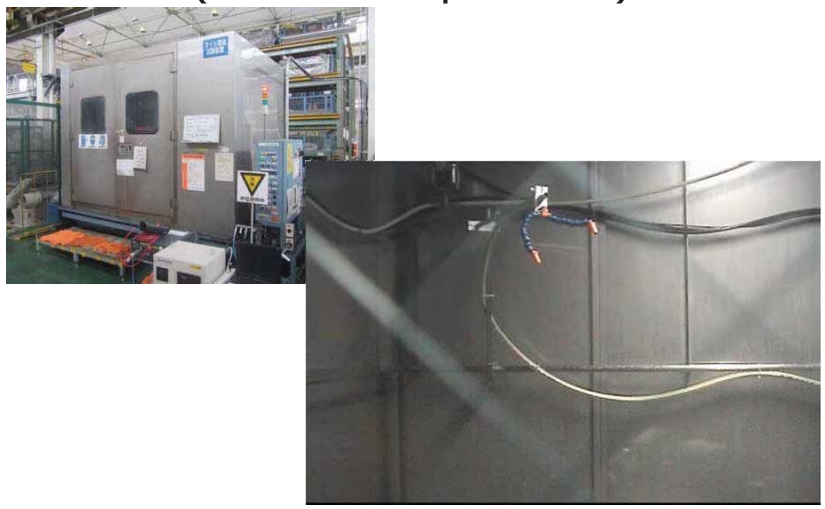




Bending and Twisting⇒ 7.5 million times

(By Courtesy of Mitsubishi Electric)

Environmental Endurance Test (Water Drip Proof)



(By Courtesy of Mitsubishi Electric)

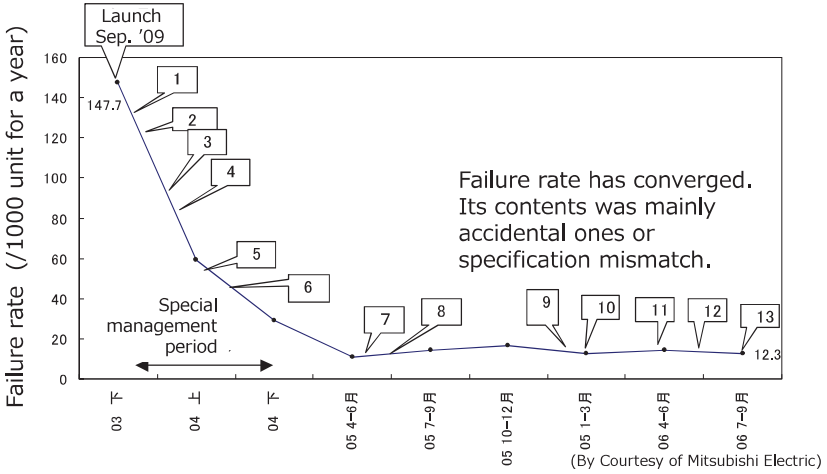
⑥Rlease Preparation

(What is needed as Commercial Product on the shelf?)

- Making Price List
- Writing Manual Materials
- Web site renewal
- Training for Service Team

⑦Initial Management and System Transferring

Monitoring product stability→transferring responsible division to manufacturing unit

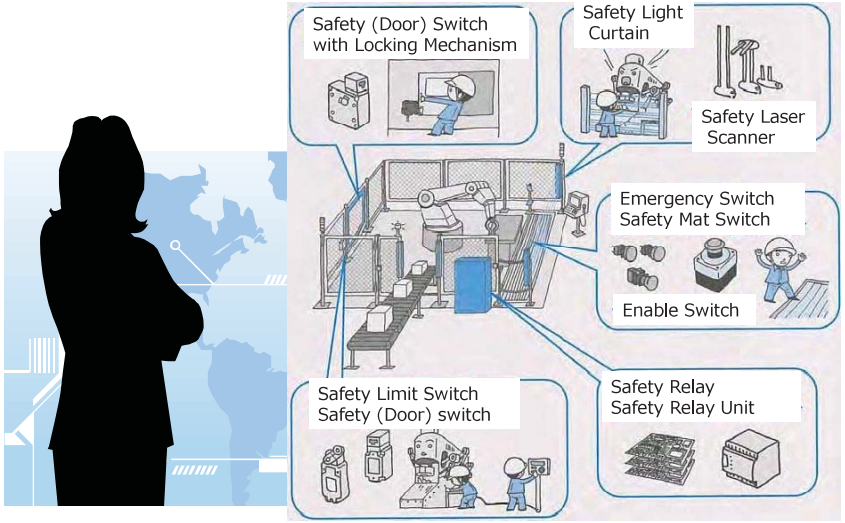


(By Courtesy of Mitsubishi Electric)

⑧Safety System Construction

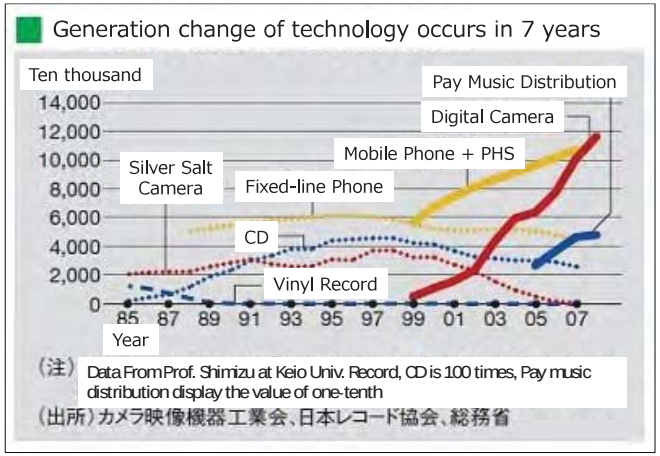
Elements of Safty System

(日本電機制御機器工業会 安全ガイドブック －製造現場における安全方策－ より)



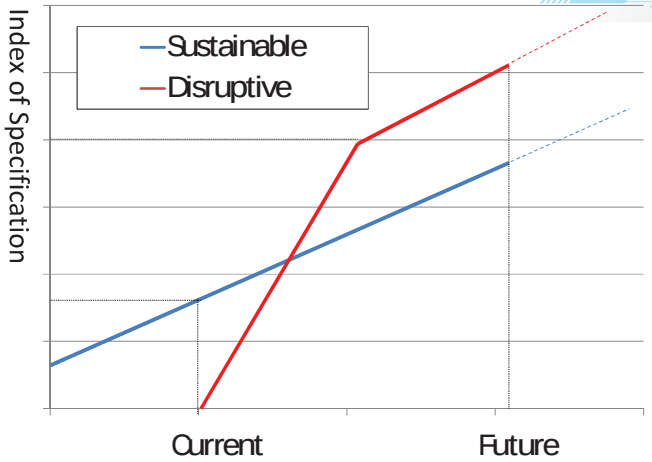
⑨The Role of Laboratory

While brushing the technology of today, working to cause the generation change of technology.



図は，「電気自動車（ＥＶ）は破壊的イノベーションになる！？　プリウス、インサイトはもう古い　- 産業・業界 - 東洋経済オンライン - 新世代リーダーのためのビジネスサイト　http://toyokeizai.net/articles/-/9978?page=3」より

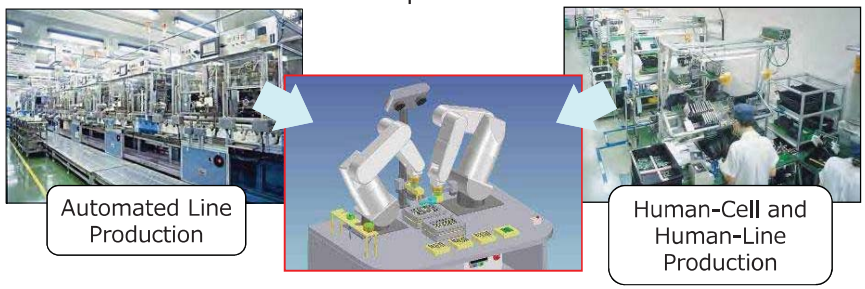
Innovation



Innovation of Production System by the Robot Technology

Low birthrate and longevity, Work Force Reduction
Intensifying Global Conpetition

From Mass Production to variable-kind variable-quantity
Request to improvement of productivity and reinforcement of core competence



Next generation autonomous robotic cell production system
The productivity and reliability of automated lines
The flexibility of human cells and human lines

(By Courtesy of Mitsubishi Electric)

The highlight of iREX2013

- **Usefulness in the Society**
- **The Spirit as entrepreneurs, engineers, researchers**

- Background of exhibition
  - Historical, Social Demand, mission and objectives
  - The aim of design
  - How to find the problem to be solved (not can be solved)
- Elemental Technologies, Theory
  - Control Technology
  - Sensor, Information Processing
  - Mechanical Elements
- System Technology, Theory
  - Teaching and Programming
  - Safety
  - Proper use of H/W and S/W

Is there is a relationship between this time lectures and high school classes?

Relation between Robot Engineering and High School Classes

Robot Engineering	Theory	High School Class
Control System	Motion Equation (Calculus)	Physics : Body Motion
Sensor, Actuator	Transformation of the state Energy Conversion	Physics : Electromagnetic effect,
Robot Body	Materials Science Mechanics of materials	Physics: Material, physical properties
Action Planning	Interference check (Computational geometry)	Math: The distance formula of points and lines
Motion Calculation	Kinematics, inverse kinematics	Math: Vector, Matrix
Information Processing	Mathematical algorithm (analysis)	Math: Mathematics sequence
Learning	Machine learning (Statistics and analysis)	Math : Probability, Statistics
Catalogue, Manual	Document creation Presentation	Essay, Paper Foreign Language Argument, debate
Marketing	World Trends	Geography, World History

Tasks

1	対象：高速で動くロボット 課題：それらのロボットの種類及び用途	Subject: Fast moving robots Theme: Species and applications of the each robot
2	対象：大型ロボット 課題：それらのロボットの種類及び用途	Subject: large size robots Theme: Species and applications of the each robot
3	対象：小型ロボット 課題：それらのロボットの種類及び用途	Subject: Small size robots Theme: Species and applications of the each robot
4	対象：機械製品(自動車、機械部品、金属等)を扱う用途のロボット 課題：それらのロボットの種類及び働き方	Subject: Robots which handle machinery products (automobile, machinery parts, metal, etc.) Theme: Species of the each robot and how they work
5	対象：電気製品(電子部品、家電等)を扱う用途のロボット 課題：それらのロボットの種類及び働き方	Subject: Robots which handle Electric appliances (Electronic components, consumer electronics, etc.) Theme: Species of the each robot and how they work
6	対象：機械製品以外かつ電気製品以外の製品を扱う用途のロボット 課題：それらのロボットの種類及び働き方	Subject: Robots which handle products other than Electric appliances and machinery products Theme: Species of the each robot and how they work.
7	対象：物を扱うためのエンドエフェクタ(ロボット手先のハンド等の事) 課題：それらのエンドエフェクタの種類及び使われ方	Subject: End effectors (Devices attached to the wrist of the robots, such as hand) for each application Theme: Species of the each end effector and how they work
8	対象：ビジョンセンサ(テレビカメラ，３次元レーザスキャナ等)を備えるロボット 課題：ロボットが使用しているビジョンセンサの種類及びその使われ方	Subject: Robots which use vision sensors (TV camera, 3 dimensional laser scanner, etc.) Theme: Species of vision sensors used by the robots and how they work
9	対象：力センサを使っているロボット 課題：ロボットが使用している力センサの種類及びその使われ方	Subject: Robots which use force sensors Theme: Species of force sensors and how they work
10	対象：産業ロボット 課題：産業用ロボットの機構の種類及びその用途	Subject: Industrial robots Theme: Classification of mechanism types of the industrial robots and applications of the each type

MEMO

MEMO

MEMO