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PROJECT IN THE REPUBLIC OF KOREA

DP/ROK/82/031/11-54/31.9.B

# TECHNICAL REPORT : Development of Industrial Robots
## - Computer Vision Systems -

Prepared for the Government of the Republic of Korea by the United Nations Industrial Development Organization, acting as executing agency for the United Nations Development programme

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## I. EXPLANATORY NOTES

### A. Korean Currency Values

Due to strong fluctuations during the last 3 months of 1986, FEV, MAR, APR we give the buying rate mean values of won(₩) in terms of US($) and Yen(¥) (In Seoul, end of April)

| | |
|---|---|
| 1 US $ | : between ₩ 881 to 886 |
| 100 ¥ | : " ₩ 485.7 to 527.03 |

### B. Technical Abbreviations

| | | |
|---|---|---|
| NC Machine | : | Numerical Control Machine. |
| CNC SYSTEM | : | Computerized Numerical Control System. |
| CAD/CAM | : | Computer Aided Design/Computer Aided Manufacturing. |
| FMS | : | Flexible Manufacturing System. |
| CIM | : | Computer Integrated Manufacturing. |
| VLSI | : | Very Large Scale Integrated (Circuit) |
| PTP SYSTEM | : | Point to Point System. |
| A.I. | : | Artificial Intelligence. |
| SCARA ROBOT | : | Selective Compliance Assembly Robot Arm Robot |

### Organizations and Companies

KIMM : Korean Institute of Machinery and Metals

MOST : Ministry of Sciences and Technology

KHIC : Korea Heavy Industries Co.

SNU : Seoul National University

## I. ACKNOWLEDGEMENTS

I would like to express my gratitude and thanks to the management members of the Korea Institute of Machinery and Metals, KIMM, as well as to the NC-Center Research Engineers group for its active cooperation, assistance and support in efforts to carry out my mission.

I am much obliged to Dr. Sam-Jin PARK the UNDP Project Director and to Dr. Chan Woong BAHK Project Coordinator and I am indebted to Mr. Seon-Il KIM who has implemented and tested usefull algorithms.

## III. INTRODUCTION

This report will cover the activities and recommendations in accordance with the objective of "Expert in Robotics". A copy of JOB-DESCRIPTION (see reference on cover-page) is attached to this report. It is important to notice the difference of time between the Description issue (July 84) and the beginning of my mission at KIMM (Feb. 86) This time lag gives an explanation to my main activity mostly oriented to "Computer Vision Systems" rather than to "Software Development for articulated robot control" as previously expected.

The evolution in Robotics Research Programs seems presently very justified because now the Robotics group at KIMM needs knowledge and pratice in Robot Vision.

Thus the scope of the mission goals has been outlined after updating the job description and after discussion with the Robotics group project coordinator.

What is the situation of Robotics Research at the KIMM :

In 1981 a Pneumatic Manipulator has been successfully developed, this machine called KIMMBOT-1 works in connexion with a rotating table. Manipulator and table motions are synchronized by a microprocessor INTEL 8085 control unit.

This manipulator has been designed for piece-working automation and loading-unloading manipulation(in the small and middle size industries). It was the first opportunity for the KIMM to localize basic robotics technologies as :

- Robot Dynamics and Kinematics.
- Pneumatic Effector Properties.
- Microprocessor Control Unit.

This project was supported by MOST ; the feasibility of such a manipulator was well demonstrated and was the starting point for a second important project concerning a 6-axes articulated robot.

This new robot model KIMMBOT-II, has the following specifications:

- 6 d.o.f
- 6 AC-brushless servomotor
- Payload : up to 20 kg
- Speed : 2m/s
- Position accuracy : 0.04mm
- Repeatibility : 0.2 mm
- Dimension height : 1330mm
  width : 814mm
- Learning : teaching pendant and console

The above features give KIMMBOT-I a very reasonnable place among the international equivalents. Presently it is in a testing stage for industrial application and already it has resolved trajectory interpolation problems such as PTP positionning and continuous path tracking.
Its 6 AC-brushless servomotors is a technical approach giving KIMMBOT-I advantages for maintenance and flexibility.
The project has been supported by KIMM, SNU and different robot industries as :

- GOLDSTAR Inc., DAEWOO Heavy Industries, SAMSUNG Precision Industries for development of part technologies.

- GOLDSTAR Inc. for Robot Vision system.
- DAEWOO H.I. for servomechanisms.

In order to improve the KIMMBOT-II capabilities and efficiency further research efforts would be concentrated on the development of new technologies, said the project manager, Mr. BAHK.
In this direction we may point out different domains :

a. Man-machine dialogue
   . High level programming language.
   . Teaching methods.

b. Sensor technology

   This domain is important to enable robot to operate in a changing environment. Sensor and A.I. algorithms make real-time decisions and might change the programmed sequence of operations. Robot equipped with sensors and A.I. algorithms is the new generation robot, operating with the help of a closed-loop control system. Here are the different types of sensor to be developed in the future :
   - Contact sensor.
   - Sensors based on I.R., ultrasonic, eddy current properties.
   - Computer vision system sensor.

The last topic, Computer Vision, is the subject on which I have focused my main activities.

## IV. ACTIVITIES

According to the duties description I have divided my schedule in several activities :

- Lectures or seminar at the KIMM.
- Technical Discussions.
- Contacts with Korean Industries.
- Visits of R & D Centers and Plants.

A. PREPARATION and PRESENTATION of LECTURES or SEMINARS

in order to instruct and advise the Research Engineers in the particular domains of the Computer Vision applied to Robotics. Listed below are the lectures given at the KIMM, Changwon Center (For more details see Annexes)

1. Perspective Camera View.
2. Image Detection, Template Matching & Understanding System.
3. Part Recognition (I)-Polar Signature Method.
4. Part Recognition (I)-Modeling and Labeling Method.
5. Recognition of a workpiece.
   Set of Algorithms.
6. Nuclear power plants in the future.
   Robotics Application : Teleoperators in Hostile Environment.
7. Introduction to Path-Finding .
8. Image Encoding by QUADTREE.
9. Obstacle Avoidance Using an OCTREE.
10. Configuration Space Approach .
11. 3-D Optical Sensor & Visual Seam-Tracking System for Arc Welding Robot.
12. Obstacle Representation in High-Level Language Algorithms in PASCAL-Introduction to LISP.
13. Introduction to Robot-Languages : AL and LM (French Version)

All the subjects deal with the robotics and its applications but on one hand an important emphasis was placed on vision problems like Image Processing, Object Recognition, Image Encoding and on the other on obstacle avoidance.
Some introductions have been given to languages either for obstacle representation in the robot joint space or for robot control.

B. TECHNICAL DISCUSIONS

A large number of technical cousultations have been given in particular to Mr. KIM Seon-Il, in order to carry out basic ideas presented in the successive lectures.
The final goal was inplementation and testing of different algorithms concerning the computer vision. At the KIMM Robotics Lab, Vision Equipments are available and consist of a camera connected to a memory-enhanced IBM-PC like Computer. These vision facilities give the possibility to prove in non completely achieved form the validity and reliability of our ideas.

A co-operatior program was decided and applied all along the mission ; here are the outlines;

1st week : Comparative study on pattern recognition approaches.

2nd to 4th week : Recognition algorithms for electronics components (Feature selection, Position/ Orientation detection, Expansion of testing objects).

5th and 6th : Algorithm Implementation.

7th and 8th : Debugging.

9th to 10th week : Application Programs.

C. A Third Part of Activities is concerned by contacts, at the KIMM, with Korean Industries like SAMSUNG Precision from CHANGWON, DAEWOO Ind. and GOLDSTAR Electronics from SEOUL. Two meetings with industry engineers and managers came off at KIMM and gave rise to projection of videotapes and transparencies. The discussed topics were in relation with studied and made in FRANCE products referring to the following domains :

a - Telemanipulators in Hostile Environment
(Example of nuclear plant dismantlement)

b - Telemanipulator MA 23, CEA Licensed and manufactured by LA CALHENE Co.

- MA 23 is a MASTER/SLAVE Manipulator (6 d.o.f).
- It is equipped with a force-feedback control system.
- Payload up to 25kg ; Integrated computer SOLAR 1675.
- Gripper equipped with infrared sensor and stress-gauge.
- Special Feature ; All mechanical commands are operated by cables, tendons and belts.
  The cable elasticity increases the compliance of the whole telemanipulator.

c - Robot Motion Control System

Several robots equipped with control systems were presented by videotape projection. Each control system is characterized by a specific sensor corresponding to a given task and using different principles as :

- Ultrasonic waves for remote control.
- Eddy current effect for Arc Welding Robot.
- Infrared waves for proximity path-tracking.

All the presentations of such technical data and advanced products aimed to promote new technologies. Sincerely we think that meetings between Industry engineer staffs and foreign experts may give incentives for developing new products and meanwhile create fruitfull ties and transferts of technology between Korean and foreign Companies.

## D. VISIT of R & D CENTERS and PLANTS

The last but not least part of my activities has been full up of visits to some important R and D Centers and Plants as well in CHANGWON area as in SEOUL vicinity in chronological order listed below are the visits :

- SAMSUNG Precision Ind. ; CHANGWON Indust. Complex.
- KHIC and FRAMATOME Facilities ; MASAN and CHANGWON Indust. Complex.
- SAMSUNG Semiconductor & Telecommunication Co. ; CHUNG-KU, SEOUL
- GOLDSTAR Semiconductor Ltd ; ANYANG-SI, SEOUL
- HYUNDAI Electronics Co. ; ICHON, SEOUL
- ANAM Industrial Co. ; SEOUL City

(For more information see Annexes)

When we scan the visit-list we observe an emphasis on the Microelectronics Industry.

This choice was not made at random but I think with the KIMM Robotics Lab Manager that the Microelectronics Technology is going to need very performing robots for the next future. This branch of industry rather than anyone is concerned by automation and productivity problems. In the present time a VLSI-wafer fabrication line has a mean value of YIELD between 10 and 20% as well in Korean Industries as in others. It is still a very low rate and in order to improve the yield and to produce more elaborated chips as well, the semiconductors industry necessarely will steer for Flexible Manufacturing Systems. And such FMS combined with automatic assembly and product inspection on one hand and CAD/CAM systems on the other, are the basic component of the HI-TECH Semiconductors factories in the next years.

## V. RECOMMENDATIONS AND CONCLUSIONS

In such a period as 2 or 3 months, instruction programs by a foreign expert in a specific field consist of basic and theoretical knowledges to give the trainees a general understanding. This expert assistance essentially given by open lectures and personal advices must be followed by a longer period of practical applications (6 months through 1 year) or until the completion of the specific project undertaken. This effort should be accomplished at KIMM otherwise the expert assistance could be forgotten and finally lost.

In the particular case of Computer Vision, developed and presented at KIMM, the few people involved in this field have to go on until project completion, i.e. achievement of a computer vision sensor able to recognize electronics components or small details of a component.

In general at KIMM, research projects must be directed and supported by a client industrial company eventually under guidance of a foreign expert. In this way research is more valuable than building up a technical Database for localizing basic technologies. It is significant to observe that a private company like DAEWOO H.I. in INCHON, has already developed and manufactured an industrial type of Welding Robot (10 exported to the U.S.A) and it is the same with SAMSUNG Precision that has developed for its own need WISEMAN* a SCARA Robot, BALAMAN a pneumatic manipulator and HOPEMAN a welding robot.

Applied research must be in close relationship with industry otherwise there is a major risk to observe difference between lagging Research Instituts and going ahead industrial Research Centers.

It was a pleasure to co-operate with the KIMM staffs and in particular with the young generation of Research Engineers who are well educated and open to the new robot technology.

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* Commercially available product

ANNEXE I

# UNITED NATIONS

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO

INTERNAL

4 July 1984

PROJECT IN THE REPUBLIC OF KOREA

## JOB DESCRIPTION

DP/ROK/82/031/11-54/31.9.B

| | |
|---|---|
| Post title | Expert in Robotics |
| Duration | 3 months |
| Date required | AS SOON AS POSSIBLE |
| Duty station | Changwon City, with travel within the country |
| Purpose of project | |
| Duties | The expert, in close co-operation with the staff of the NC Centre, will assist the research engineers who are involved in the project titled 'Development of the Industrial Robot'. He will be expected to instruct and advise the engineers of the NC Centre and industries in the fields of: |

1. Software development for articulated robot control, which includes algorithms for path interpolation in assembler and high level languages for articulated robot motion control of 6 degrees of freedom.
2. Computer graphic simulation of robot kinematics and dynamics.
3. Hybrid compliance, which includes the simultaneous control of force and position of end effector which is essential to the assembly process.
4. The expert will also be expected to prepare a final report, setting out the findings of the mission and recommendations to the Governme on further action which might be taken.

The expert's instruction and assistance should be practical and capable of being adapted to the industrial robot.

..../..

Applications and communications regarding this Job Description should be sent to:

Qualifications

**The expert is required to have experience of more than 5 years in robotics, especially software writing for robot controller and application software. In addition he should have an appropriate technical university degree.**

Language

English

Background information

One of the major national goals as outlined in the Fifth Five-Year Economic Development Plan (1982 - 1986) of the Republic of Korea is to achieve significant growth and diversification in the heavy industry sector. In order to achieve this goal, the Government is placing heavy emphasis on developing and applying key technologies. Particular attention will be given to more intensive applications of computer assisted manufacturing techniques such as numerical contr (N/C) machining, automation and robotics, to improve productivity, product quality and reliability and to strengthen the country's capital goods industry. In addition, the Fifth Plan calls for a large increase in machinery exports which requires the promotion of indigenous designs of machine tools, equipped with N/C systems in order to be competitive in the world markets.

In order to provide support for the achievement of the national development objectives, a numerical control centre has been established at the Korea Institute of Machinery and Metals in Changwon, Gyeons Sans Nam Do province in the south of the Republic, where a large portion of the nation's heavy, metalworking and machinery industry in enhancing the utilization and production of N/C tools domestically, carrying out research and development projects, N/C software development and consultation and training for industry is situated.

The Korea Institute of Machinery and Metals is one of the major research and development institutes in Korea, concentrating on the machine industry, metal industry and shipbuilding industry by providing techni guidance and training, calibration, testing and inspection services and assisting industry in the acquisition and adaptation of advanced technology.

# ANNEXES II

## LECTURES at KIMM

### ① PERSPECTIVE CAMERA VIEW

SUMMARY OF SPACE TRANSFORMS.
Rotation & Translation Matrix.
Implementation of the T6 Transform (6 axes).
Jacobian Matrix.
Petspective Transform.
Algotithms applied to a Cube in various otientation.
Cube - Cameta Transform.

### ② IMAGE DETECTION - TEMP :TE MATCHING & UNDERSTANDING SYSTEMS

1. Practical Applications and Goals of Image Detection and Feature Extraction.

   - Right Aplication : Object Recognition Localization Classification and Sorting.
   - Wrong Application : Arc Welding Joint Tracking, Cutting Line Tracking.

2. Template Matching - Feature Extraction applied to a digitized image.

   $D(m,n)$ = difference measure between Pattern and Image.

   D = Image Energy + Cross-Cottelation + Pattern energy

   Calculation Saving factots:
   - Framing the Object.
   - Contour extraction.

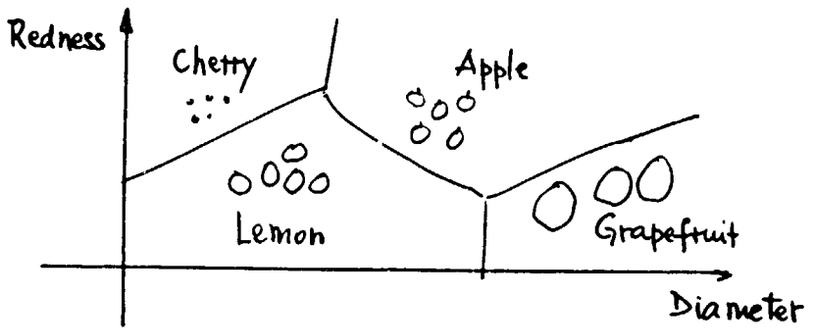
3. Image Understanding Systems

Designed to Classify an input-pattern into several CATEGORIES or CLASSES.

Pattern Recognition Process ⇒ 3 Phases:

- Object Isolation
- Feature Extraction
- Object classification

Example : a Fruit-Sorter

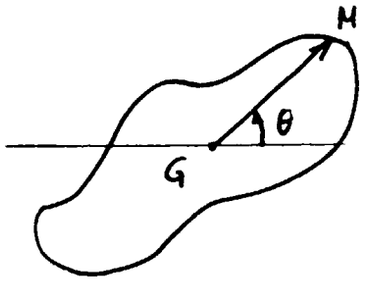



## (3) PART RECOGNITION (1) - POLAR SIGNATURE APPROACH.

The 4 Stages of Industrial Scene Recognition:

- Sensing and Preprocessing.
  (Image Acquisition - Noise & Brightness correction)
- Segmentation.
  = Edge Detection by Thresholding by moving a Template (3 x 3 pixels) according to different methods, all based on gradient principle:
  ROBERTS, SOBEL, KIRSCH, ..

Necessity of "Thinning" a Contour -




POLAR SIGNATURE Method consists in a radially sweeping of contour from the Gravity Center G of a given object.

$\underline{GM} = \underline{GM}(\theta)$ : "signature"

After searching the Maximal Symetry Axis, SIGNATURE is compared with a model and gives the object recognition.

## (4) PART RECOGNITION (II) - MODELING & LABELING

1. SELECTING A DESCRIPTORS SET.

Descriptors = Features such as Surface Area A, Petimeter P, Compactness $P^2/A$ Centroid, Diagonal distance Eulet Number, etc ...

2. Decision - Theoretical Approach.

A Vision System makes DECISION by Matching descriptors with Features. Methods such as:

- Classification Tree.
- Parametric Pattern Classification.
- Minimal Euclidian Distance Classification.

The parametric Recognition Method is mostly a numerical one using such notions as:

CLASS : $O : \{ O_1 \; O_2 \; O_3 \ldots O_M \}$

UNKNOW OBJECT : $X = [X_1 \; X_2 \; X_3 \ldots X_N]^T$

MODEL OBJECT : $Y^K_{im} = [Y^K_{1m} \ldots Y^K_{im} \ldots Y^K_{N,MK}]^T$

(5) RECOGNITION OF A WORKPIECE
SET OF ALGORITHMS

The problem is to recognize which side of a Connecting-rod faces up. The rod is laid on a work-table and must be correctly gripped by a Robot Arm.

- Identify the Part's position and orientation by:
  Procedures : FRAME (BOUND + FORM)
  ANGLE (INCLINX OR Y)
- Draw a Line along the main axis
  (XLINE OR YLINE)
- Analyse the Pixel values along the Line
  (WHATSIDE)

(6) NUCLEAR POWER PLANTS in the Future.
TELEOPERATORS IN HOSTILE ENVIRONMENTS.

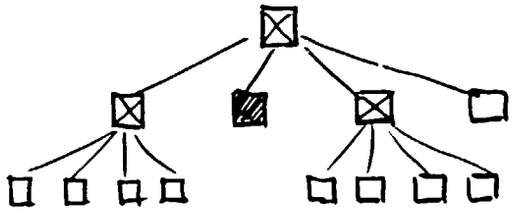
- Nuclear Energy in FRANCE (1985)
  - PWR Units
  - FAST NEUTRONS BREEDER UNITS (SUPERPHENIX)
- Nuclear Energy Industry needs Adaptive Robots.
  - Telemanipulator
  - Maintenance Robot
  - Rescue-operation Robot
    " " Vehicule.

## (7) INTRODUCTION TO PATH-FINDING

- Problem Description : in a bidimensional space to find a Path among obstacles is to go free from Start-point S to Goal-point G avoiding all obstacles.
- Description of the Free-Space, Voronoi-Diagram.
- Free Space as Generalized Cones.
- Free Space as Channel Volume.
- Obstacle avoidance Algorithms
  Notion of HEURISTIC fonctions.

## (8) IMAGE ENCODING by QUADTREE

- Quad-Tree Approach in 2-D geometric Structure ( $2^n \times 2^n$ pixels image )
- Simple Algorithm for QUADTREE Genetation.



Principle : 3 kinds of node make a TREE :
GRAY, WHITE, BLACK.
ONLY the GRAY nodes are divided in Sub-nodes
White & Black node ⇒ leaves

- Practical Algorithms in PASCAL Language.

## (9) OBSTACLE AVOIDANCE USING an OCTREE.

- TREE is HIERARCHICAL Representation of Space. A Volume of $2^n \times 2^n \times 2^n$ VOXELS is transformed into a OCTREE. Voxel is elementary volume and NODE is made of voxels. In Space NODE is FULL, EMPTY or MIXED. ONLY MIXED Node is divided in 8-Subnodes.

- OCTREE Description of a Robotic Cell made of
  - True Obstacles (Machines tools, conveyors, ...)
  - Fictive Obstacles (non steady objects)
  - Robot Gripper
  - Workpiece.

- OCTREE Representation advantages are:
  - Homogeneous Form in the Robot-Joint-Space.
  - Fast Computer Transform.

- Searching a Path - Algorithm.

## (10) CONFIGURATION SPACE APPROACH.

- For Obstacle Avoidance there is a trick to transform the Problem into a Simplifying Representation. Transformation consists to go from the Space of moving object and obstacles to the Space of moving point and Virtual Obstacles called "CONFIGURATION-SPACE OBJECTS".

Configuration : Position + Orientation of a Rigid Object A specified by a single n-dimensional Vector ; that Vector is called " CONFIGURATION of A".

Example : in 2-D Space, Configuration is specified by $(X\ Y, \theta)$ with $X, Y$ = position, $\theta$ = rotation

Algorithms of Pathfinding.

## (11) 3-D OPTICAL SENSOR & VISUAL SEAM-TRACKING SYSTEM For ARC WELDING ROBOT.

### 1. Sensor Description

A given Scene Surface is scanned by a LASER Beam ; Simultaneous knowledge of both Directions of beam projection and Reception allows to compute the 3-D coordinates of a 256 x 256 pixels image.

| | |
|---|---|
| Visual Field | : 600 x 1200 mm. |
| Signal Acquisition | : 500 msec. |
| Image Computing | : 10 sec. |

### 2. Seam Finder & Joint Tracker

- Seam Finder : ASEA™ System. using IR Laser Beam Triangulation.
- Seam Tracker : MITSUBISHI™ System. same principle.

### 3. Remarks

- Optical Equipment needs Special Protection.
- Eddy Current Sensor is more convenient for Arc-Welding Operation.

## (12) OBSTACLE REPRESENTATION in HIGH-LEVEL LANGUAGE - Example of ALGORITHMS in PASCAL.

- Introduction to PASCAL Dynamic Structures
  - RECORD
  - POINTER
- Algorithms in PASCAL environment
  - Creating POLYGONS
  - Creating QUADTREE
- Introduction to LISP, Language of TREE Research & Representation SYMBOL-Manipulation.

## (13) INTRODUCTION TO ROBOT COMMAND LANGUAGES : AL & LM

- AL Software.
- Programming in AL ; Reference:
  USER's Manual - STANFORD Artif. Intellig Lab Memo. AIM-323 (JAN 1979)
- LM Language ; Reference:
  Textbook by E. MAZER & J.F. MIRIBEL
  C/ CEPADUES - Editions ; France
  (French Version
  English Version available)

ANNEXES III

Visit Reports -

① SAMSUNG Precision Industries, in Ch'ang Won.

A branch of SAMSUNG Group mostly involved in High Precision Machinery Manufactuting. S.P.I is now working on the field of "Mechatronics" as Precision Military Equipment, Process Control System, Cametas, Industrial Robots (WISEMAN a SCARA Robot) and Compact-Disk Pick up Head.

② KHIC & FRAMEX, in Ch'ang Won - Masan area.

The Korea Heavy Industries and Construction Co., Ltd is an integrated industrial machine Manufacturer which is equipped with high capacity facilities to produce molding and forging products and Specially Turbine Generator and Nuclear Pressure Vessel under FRAMATOME license.
(FRAMEX is Export Branch of FRAMATOME).

③ SAMSUNG Semiconductor & Telecommunications Co., Ltd.

The visited Plant is a Branch of SST Co. which currently produces Semiconductors and Optical Fiber. This plant is capable of producing different chips such as :

64K D-RAM
16K S-RAM and 256K D-RAM

We must notice that SST will ultimately develop in 1986 the largest scale integrated circuit, the 1Mega D-RAM chip.

④ GOLDSTAR Semiconductor Ltd. in ANYANG-Si Seoul Area

The Plant located in ANYANG-si has Wafer Fabrication Assembly Lines - Wafers are manufactured in large different Clean-Rooms. The Production Capability is a wide range type of memory chip such as:

64K D-RAM
256K D-RAM

The main product is 64K S-RAM and Some customized IC.

⑤ HYUNDAi Electronics Industries Co., Ltd in ICHON, Seoul area

HYUNDAi Group is well known as a car manufacturer but H.E.I and HEA (in the USA) since 1983 are challenging the semiconductor world. Product Lines have 2 divisions:

Division I will use a double-poly process technology and will produce CMOS and NMOS devices such as: memory logic microprocessor and custom designed circuits. The manufacturing facility will feature a 5-inch Wafer stepper and an all-dry etching process occupying 200.000 sq.ft. Such equipment are also backed up by in-house CAD system and "class 100" clean-room (up to 10 for lithography)

Division II is for assembly and testing, using

the most up-to-date equipment which will support memory test, VLSI burn-in, autowire and die bonding, tin plating,.. The facilities will occupy 230 400 sq. ft.

Division I Plant has a annual production capacity of 200.000 units of 5-inch wafers; Division II a capacity up to 30 million units / month.

The products will include S-RAM, ROM, E-EPROM microcontroller and custom-designed chips.

## ⑥ ANAM Industrial Co., Ltd - in Seoul City.

The main plant is in Seoul, but the Company has 5 other plants in BUCHON and INCHEON. One Branch is american and settled in ValleyForge, PA SAN MATEO, CA and DALLAS, TX - its name is AMKOR Electronics Inc.

ANAM is the most experienced and highly automated independant Semiconductor Assembly Company in the world. Listed below are products:

- Plastic encapsulated devices
  - Dual in-line I.C.
  - PLCC (Plastic leaded Chip Carriers)
  - Soic packages
- CER-DIP
  - Dual in-line
  - leaded chip carriers
- Solder sealed hermetics
- Metal-can devices
- Hybrid
- Opto displays

Considering the lifetime of equipment investment ANAM's people said every 3 years, mean value, the machines are changed for new & up-to-date ones.