
UNIVERSITI PUTRA MALAYSIA

# ROBOTIC SYSTEM FOR HAZARDOUS CHEMICAL EXPERIMENT

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**By**

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**ROBOTIC SYSTEM FOR HAZARDOUS CHEMICAL EXPERIMENT**

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**Chairman:** **Dr. Ishak Bin Aris**

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Normally the experiments conducted in laboratories are done manually. This may lead to unpredictable accidents. It can cause damage to both experiment apparatus and its user. Results obtained from the experiment conducted manually are not accurate especially if the same experiment has to be repeated for many times. This technique needs to be improved.

The main objective of this project is to provide a robotic system that is capable of handling hazardous chemical processing and experiments at laboratories. It can be reprogrammed to perform various tasks with flexible degrees of freedom. This

system is called Robolab. This project starts from the development of a simple concept of XYZ movements and gripper, into a final form of a Cartesian robot.

The main structure of the Robolab can be divided into software and hardware parts. The software is responsible to drive the robotic arms in order to move to a precise position and at the same time control the inputs and outputs devices of the system. The program consists of various functions such as home routine, stop routine, process routine, jog/manual routine and on-error routine. Meanwhile, the hardware of the Robolab system can be divided into electrical and mechanical modules.

The electrical module consists of a power distribution system, a SmartStep/3 control board and a personal computer. The mechanical consists of an end effector, a pneumatic system, a Z-axis module, a Y-axis module, an X-axis module, a pipette module, a vibrator module, a conveyor belt system, a system base and jigs and fixtures module.

A personal computer is needed to download program into the EPROM of the motion controller through the connection of RS232 host link system. The motion controller acts as the main processor of the robotic system. The actuators are used to drive the mechanical robotic arm. This robot also has a built-in fault detection system. It will inform its main controller if any particular faults occur to the system.

The SmartStep/3 controller is chosen for this project to control the robot. CTERM, a terminal emulator is specially configured for the controller to use on PC. MINT's flexible and powerful command set is used as a solution to motion control applications.

From the experimental results, it is proven that the proposed robotic arm was successfully designed, constructed and controlled.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untk ijazah Master Sains

**SISTEM ROBOTIK UNTUK UJIKAJI BAHAN KIMIA MERBAHAYA**

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Lazimnya, eksperimen-eksperimen di dalam makmal-makmal dilakukan secara manual. Ini mungkin membawa kepada kemalangan yang tidak dapat dijangka. la, boleh menyebabkan kerosakan pada bahan eksperimen dan mengancam keselamatan pengguna. Selain itu, keputusan-keputusan yang diperolehi daripada eksperimen yang dijalankan secara manual adalah kurang tepat khususnya apabila eksperimen yang sama perlu banyak diulang. Jadi, teknik ini perlu diperbaiki.

Tujuan utama yang mendorong kepada pembinaan projek ini adalah untuk merekacipta suatu sistem yang mampu mengendalikan pemprosesan dan pengujian bahan kimia yang berbahaya di makmal-makmal. lanya boleh diaturcarakan untuk

melakukan pelbagai jenis tugas dengan darjah kebebasan yang fleksibel. Sistem ini dikenali sebagai Robolab. Projek ini bermula dari pembangunan satu konsep mudah pergerakan XYZ, sehinggalah ke suatu bentuk robot jenis Kartesian.

Proses penghasilan projek ini melibatkan pembangunan bahagian perisian dan bahagian perkakasan. Bahagian perisian bertanggungjawab untuk mengawal kedudukan lengan robot dengan tepat dan pada masa yang sama dapat mengawal peranti-peranti masukan serta keluaran sistem ini dengan bijak. Program yang ditulis mengandungi pelbagai fungsi seperti rutin asalan, rutin reset, rutin proses, rutin manual dan juga rutin semasa ralat. Sementara itu, perkakasan untuk sistem Robolab boleh dibahagikan kepada modul elektrikal dan modul mekanikal.

Modul elektrikal merangkumi sistem pengagihan kuasa, pengawal SmartStep/3 dan komputer. Bahagian mekanikal meliputi pencengkam, sistem pneumatik, modul paksi Z, modul paksi Y, modul paksi X, modul pipet, modul penggegar, sistem konveyor, tapak dan modul 'jigs and fixtures'.

Sebuah komputer diperlukan untuk memasukkan program yang ditulis ke dalam EPROM pada pengawal melalui rangkaian RS232. Pengawal gerakan ini bertindak seperti pemproses; utama kepada sistem robotik ini. Penggerak digunakan untuk memacu segala pergerakan yang diarahkan. Sistem ini juga mempunyai pengesan ralat dalaman, dimana sistem kawalan utama akan bertindak sekiranya berlaku ralat di dalam sistem keseluruhan.

Sistem kawalan SmartStep/3 telah dipilih dalam projek ini untuk mengawal robot. CTERM, suatu 'terminal emulator', dikonfigurasikan supaya sistem kawalan dapat digunakan dengan komputer. MINT ialah suatu bahasa tahap tinggi yang mampu memberikan penyelesaian kepada penggunaan yang luas di dalam industri kawalan pergerakan.

Daripada keputusan ujikaji yang dijalankan, ternyata bahawa sistem robot ini berjaya direkabentuk, dibina dan dikawal.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AC | Alternative Current |
| ACL | Advanced Control Language |
| ADC | Analog to Digital Converter |
| ATS | Advanced Terminal Software |
| CB | Circuit Breaker |
| CP | Continuous Path |
| CPU | Central Processing Unit |
| 3D | Three Dimension |
| DAC | Digital to Analog Converter |
| DC | Direct Current |
| DIR | Direction |
| ELCB | Earth Leakage Circuit Breaker |
| EPROM | Erasable Programmable Read Only Memory |
| GND | Ground |
| IC | Integrated Circuit |
| I/O | Input and Output |
| MCB | Miniature Circuit Breaker |
| MCU | Microcontroller Unit |
| MINT | Motion Interpreter |
| PC | Personal Computer |
| PLC | Programmable Logic Controller |

| | |
|---|---|
| PLS | Pulse |
| PM | Programmer and Monitor |
| RAM | Random Access Memory |
| RST | Reset |

# LIST OF SYMBOLS

| | |
|---|---|
| A | Ampere |
| COM | Common |
| D | Diameter (mm) |
| F | Force (kg) |
| g | Gravity constant |
| $g_m$ | Thread angle (°) |
| $h_{wormgear}$ | Efficiency of the leadscrew |
| Hz | Hertz |
| I | Current (A) |
| J | Moment of inertia (kg $mm^2$) |
| $J_o$ | Effective moment of inertia |
| l | Length (mm) |
| m | Mass (kg) |
| $m_k$ | Friction coefficient |
| p | Pitch (revs/mm) |
| ρ | Density (kg/ $mm^3$) |
| psi | Pound per square inch |
| r | Radius (mm) |
| *r* | Frictional angle (°) |
| R | Resistance |
| rpm | Revolution per minute |
| t | Time (s) |