

Contents

| contents | Page |
|---|-------------|
| ابه | I |
| Dedication | II |
| A knowledgegement | III |
| Abstract | IV |
| خلاصه | V |
| Contents | VI |
| Table of figures | IX |
| List of tables | XI |
| List of symbols and abbreviations | XII |
| Chapter one: Introduction | |
| 1-1Robot definition | 1 |
| 1-2History of Robotics | 3 |
| 1-3Advantage and disadvantage of robots | 5 |
| 1-4 Robot applications | 6 |
| 1-5 Thesis objectives | 8 |
| 1-6 Thesis plan | 8 |
| 1-7 Thesis overviews | 9 |
| Chapter two: Theoretical Background | |
| 2-1 Introduction | 10 |
| 2-2 Classification of Robots | 10 |
| 2-3 Robot components | 11 |
| 2-3-1 Manipulator | 12 |
| 2-3-2 The end effecter | 12 |
| 2-3-3 Actuators | 12 |
| 2-3-4 Sensors | 12 |
| 2-3-5 Controller | 13 |
| 2-3-6 Processor | 13 |
| 2-3-7 Software | 13 |
| 2-4 Robot degrees of freedom | 13 |
| 2-5 Robot coordinates | 14 |
| 2-5-1 Cartesian (rectangular configuration) | 14 |
| 2-5-2 Cylindrical configuration | 15 |

| | |
|---|----|
| 2-5-3 Articulated configuration | 15 |
| 2-5-4 Spherical configuration | 16 |
| 2-5-5 Selective compliance Assembly robot arm | 16 |
| 2-6 Joints and joint notation scheme | 17 |
| 2-7 Robot end effectors | 18 |
| 2-8 Robot Actuators | 19 |
| (2-9) Robots characteristics | 22 |
| Chapter three :The Manipulator kinematics | |
| 3-1 Introduction | 23 |
| 3-2 Mechanical structure | 23 |
| 3-3 Description of link and joints | 25 |
| 3-4 Homogeneous transformation | 26 |
| 3-4-1 Point representation | 27 |
| 3-4-2 Vector representation | 27 |
| 3-4-3 Representation of a frame | 28 |
| 3-4-4 Body representation | 29 |
| 3-4-5 Representation of transform motion | 30 |
| 3-5 Kinematics modeling of the manipulator | 32 |
| 3-6 The forward kinematics – (D – H notation) | 33 |
| 3-7 The inverse kinematics | 37 |
| 3-8 Solution techniques | 39 |
| Chapter four: Kinematics Design | |
| 4-1 Manipulator description | 40 |
| 4-2 Kinematics design | 47 |
| 4-2-1 Forward kinematics analysis | 47 |
| 4-2-2 Closed form solution | 50 |
| 4-2-3 Inverse kinematics solution for the 4-(DOF) | 51 |
| Chapter5: Inverse Kinematics Solution | |
| 5-1 The position matrix | 57 |
| 5-2 The inverse solution of the arm | 58 |
| 5-3 Inverse kinematics solution | 60 |
| 5-3-1 Home position | 60 |

| | |
|--|----|
| 5-3-2 Inverse solution fore the first position | 63 |
| 5-3-3 Second position solution | 65 |
| 5-3-4 Third position solution | 66 |
| Chapter six: Results discussion | |
| 6-1 Forward kinematic solution | 68 |
| 6-2 Verification of the computer program | 69 |
| 6-3 Comparison between direct and inverse solutions | 72 |
| 6-3-1 Forward solution results | 72 |
| 6-4 Graphical simulation results | 74 |
| 6-5 Physical model analysis | 76 |
| Chapter seven: conclusion and recommendations | |
| 7-1 Conclusion | 82 |
| 7-2 Recommendations | 83 |
| References | 84 |
| Appendix A | 85 |
| Appendix B | 86 |
| Appendix C | 91 |
| Appendix D | 92 |