

Dr. Md. Nazrul Islam



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EDUCATION

- 2008 Ph.D. in Information Science (Computer Science), University of Fukui, JAPAN
Dissertation : “Backtrack Free Path Planning Algorithm for Multi-Arms Manipulators”,
Supervisor: Prof. Shinsuke Tamura
- 1998 M.Phil. in Mathematics, Bangladesh University of Engineering and Technology (BUET),
Bangladesh
Dissertation: “MHD Free Convection Flow of Visco-Elastic Fluid Past on an Infinite Vertical
Porous Plate”, Supervisor: Prof. Md. Mustafa Kamal Chowdhury
- 1994 M.Sc. in Applied Mathematics, Dhaka University, Bangladesh
- 1992 B.Sc. (Hons.) in Mathematics, Dhaka University, Bangladesh

WORK EXPERIENCES

- | | | |
|---------------------|------------------------------|--|
| Jan.2011 – to date | Senior Lecturer | Dept. of Computer Science, Faculty of Computing, University Technology Malaysia (UTM)
Topic: Path Planning Algorithm for Manipulators and Collision Detection Algorithm in Deformable Environment for Medical Robot |
| Oct.2009- Dec.2010 | Researcher | Dept. of Computer Science, Tallinn University of Technology, Estonia
Topic: Assistive Robotics, Human-Robot Interaction Modeling & Coordinated Trajectory Planning Of Two-Armed Robot's Manipulators |
| Oct.2008 - Sep.2009 | Researcher | Dept. of Computer Science, University of Verona, Italy
Topic: Robotics Motion Planning Algorithms in Deformable Environments (Medical Robotics) |
| Jan.2003 - Sep.2008 | Research/ Teaching Assistant | Dept. of Information Science, University of Fukui, Japan
Topic: Path Planning Algorithm for Multi-Arms Manipulators |
| Feb.2002 -Sep.2002 | Researcher | Dept, of Engineering, Kingston University, London, UK |

		Topic: Large Eddy Simulation of Impinging Jet Flows
Aug.2001 -Feb.2002	Researcher	Biomechanics Laboratory, Tohoku University, Sendai, Japan Topic: Numerical Simulation of Blood Flow
Sep.1997 -Aug.2001	Lecturer	Lecturer in Mathematics Dept. of Computer Science & Engineering, Stamford University, Dhaka, Bangladesh
Oct.1995 - Sep.1997	Teaching Assistant	Dept. of Mathematics, Bangladesh University of Engineering & Technology, Dhaka, Bangladesh

RESEARCH INTERESTS

Path Planning & Motion Planning Algorithm for Multi-Arms Multi-Manipulators/Robotics, Assistive Robotics, Human-Robot Interaction Modeling Coordinated Trajectory Planning of Two-Armed Robot's Manipulators, Collision Detection Algorithm in Deformable Environment for Medical Robot and Kinematics & Dynamics of Parallel Manipulators, Soft Computing.

RESEARCH EXPERIENCES/GRANTS

- Name of University **University Technology Malaysia (UTM)**
Title Evaluation of a Path Planning Algorithm for Robotics Manipulators in
3-Dimensional Environment
Duration April 2011 – Mac 2012
Sponsor/RM UTM/GUP/ RM 40,000.00
Designation Project Leader
- Name of University **University Technology Malaysia (UTM)**
Title Minimum Collision Allow Path Planning in a Deformable
Environments
Duration November 2011 – October 2012
Sponsor/RM UTM/GUP/ RM 30,000.00
Designation Project Leader
- Name of University **Tallinn University of Technology (TTU), Estonia**
Title Assistive Robotics, Human-Robot Interaction Modeling & Coordinated
Trajectory Planning Of Two-Armed Robot's Manipulators
Duration Oct.2009- Dec.2010
Sponsor/EURO European Union (EU) Project / 21,000 EURO
Designation Project Member
- Name of University **University of Verona, Italy**
Title Robotics Motion Planning Algorithms in Deformable Environments
(Medical Robotics)
Duration Oct.2008 - Sep.2009
Sponsor/EURO European Union (EU) Project/ 18,000 EURO
Designation Project Member

5	Name of University	University of Fukui, Japan
	Title	Path Planning Algorithm for Multi-Arms Manipulators
	Duration	Jan.2003 - Sep.2008
	Sponsor/Yen	Japanese Government (Monbukagakusho) Scholarship program/ 12,0000 Yen (Per-Month)
	Designation	Project Member
6	Name of University	Kingston University(KU), London, UK
	Title	Large Eddy Simulation of Impinging Jet Flows
	Duration	Feb.2002 -Sep.2002
	Sponsor/British Pound	Overseas Research Students Awards, KU/830GBP(Per month)
	Designation	Project Member
7	Name of University	Tohoku University, Sendai, Japan
	Title	Numerical Simulation of Blood Flow
	Duration	Aug.2001 -Feb.2002
	Sponsor/Yen	Japanese Government (Monbukagakusho) Scholarship program/ 10,0000 Yen (Per-Month)
	Designation	Project Member
7	Name of University	Bangladesh University of Engineering and Technology (BUET)
	Title	<u>MHD Free Convection Flow of Visco-Elastic Fluid Past on an Infinite Vertical Porous Plate</u>
	Duration	March.1995 –Dec. 1998
	Sponsor/Taka	BUET/5000 TK
	Designation	Project Member

TEACHING EXPERIENCES 1995– 2013

University Technology Malaysia, Malaysia

Year	Semester	Name of Subjects	OMR (max score: 5.00)		
			My	Faculty	UTM
2013	II	Probability & Statistical Data Analysis			
2013	II	Data Structures			
2012	I	Theory of Computer Science	4.11	4.24	4.34
2012	I	Basic C Programming I Basic C	4.28	4.29	4.35
2012	II	Object Oriented Programming	4.15	4.21	4.28
2012	II	Computational Mathematics	4.37	4.21	4.37
2011	I	Basic C Programming I Basic C	4.25	4.29	4.35
2011	I	Discrete Structures	4.37	4.21	4.37
2011	II	Programming Technique II C++	4.24	4.28	4.34

2011	II	IT Management	4.27	4.29	4.37
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University of Fukui, Japan

Year	Semester	Name of Subjects
2006	April-September	System Software, Avanced
2005-06	October-March	Reliable Systems
2004	April-September	Advanced Information Base System
2003-04	October-March	Programming Technique II C++
2003	April-September	JAVA Programming

Stamford University, Dhaka, Bangladesh

Year	Name of Subjects
Oct.1997 – Aug. 2001	Discrete Structures, Computational Mathematics, Operations Research, JAVA Programming, FORTRAN, Fluid Mechanics, Linear Algebra, Vector Analysis, Complex Variable, Differential Geometry, Introduction to Calculus, Integral Calculus, Differential Calculus, Differential Equation, Partial Differential Equation, Mathematical Method, Laplace Transform, Fourier analysis, Discrete Mathematics, Numerical Analysis

Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh

Year	Name of Subjects
Mar.1995 – Sep.1997	Mathematical Method, Laplace Transform, Fourier analysis, Special Function & Integral Transforms, Similarity Analysis, Quantum Mechanics

I am able to teach on the below subjects also

Similarity Analysis, Quantum Mechanics, Statistical Data Analysis, Quality Control, Computer Science Theory, Robotics, Numerical Methods, Probability and Statistics, Modeling and Simulation

COLLABORATION RESEARCH

Jan.2003 – to date	Researcher	Kinematics and Dynamics of Parallel Manipulators Department of Mechanical Engineering, Instituto Tecnolo`gico de Celaya, Mexico
Apr.2004 –Dec.2006	Researcher	MAEDA Company Ltd., Harua City , Fukui, Japan

SUPERVISION: Ph.D.

University Technology Malaysia, Malaysia

Year	Name	Project Title	Date	Role
2012	Mohsen Mahrami	Apply Evolutionary Algorithm (Genetic Algorithm) for Mobile Robot Simultaneous Localization and Mapping	Estimated December 2015	Main Supervisor

SUPERVISION: Master

University Technology Malaysia, Malaysia

Year	Name	Project Title	Date	Role
2011	Liyana 'Adilla Burhanuddin	Collision Avoidance Path Planning Algorithm for Multi Manipulators by using Minimum Distance Technique	Estimated September 2013	First Supervisor
2011	Fakhrul Syakirin Bin Omar	Minimum Collision Allow Path Planning in a Deformable Environments	Estimated September 2014	First Supervisor
2011	Anis Fadhillah Binti Hassan	Path planning Algorithm for multi-manipulator in dynamic environment	Estimated February 2014	First Supervisor
2011	Chang Yung Khien	Development of Web-Based Material Requirements Planning System for Sunderland Bakery SDN. BHD.	Finished	First Supervisor

OTHER INFORMATION

Computing Skills:

- ☐ Programming: Java, C, C++, Fortran 90
- ☐ Commercial Software: Microsoft Office XP, Linux, Microsoft word, Microsoft Office Excel

Membership of Professional Bodies:

- ☐ The Japan Society of Mechanical Engineers (JSME)
- ☐ The American Society of Mechanical Engineers (ASME)

Professional Appointment

- ☐ 2007-Lifetime Honorable Fukui Friendship Ambassador
Offering Body: Fukui Friendship Ambassador, International Affairs &
Marketing Strategy Division, Fukui Prefecture Government,
Japan

Hobbies and Interests

- ☐ Reading Book
- ☐ Playing football and volleyball

Languages

- ☐ Native Language Bangla : Very Good
- ☐ English : Very Good
- ☐ Japanese : Good

Reviewer of International Journal for the Editorial Board:

Number	Year	Name of Journal
1	2012	International Journal of Advanced Robotic Systems

Session Chair/Reviewer for Conference Articles

Year	Number of papers reviewed	Name of Conference
2013	6	Asian Conference on Intelligent Information and Database System (ACIIDS 2013) 2013, 18-20 March, Kuala Lumpur, Malaysia
2012	5	International Conference on Engineering and ICT (ICET 2012, 4 to 6 April), Melaka, Malaysia
2011	4	International Conference on Research and Innovation in Information Systems – 2011 (ICRIIS'11) of IEEE, Kuala Lumpur, Malaysia
2011	6	International Visual Informatics Conference, Salangor, Malaysia

PUBLICATIONS

Journal Papers

1. Mohsen Mahrami, **Md Nazrul Islam** and Ramin Karimi, "Simultaneous Localization And Mapping:Issues and Approaches" submitted in International Journal of Computer Science and Telecommunications in May 2013.
2. **Md. Nazrul Islam** and Liyana 'Adilla Burhanuddin, "Collision Avoidance Path Planning Algorithm for Manipulators based on Minimum Distance Technique", submitted in Journal of Intelligent Manufacturing 2013.
3. Hossein Rajabalipour Cheshmehgaz, **Md. Nazrul Islam**, Mohammd Ishak Desa "A Polar-based Guided Multi-objective Evolutionary Algorithm to Search for Optimal Solutions Interested by Decision-makers in a Logistics Network Design Problem" published (online 29th November 2012) in Journal of Intelligent Manufacturing 2012.
4. **Md. Nazrul Islam**, Shinsuke Tamura, Tomoya Murata and Tatsuro Yanase "Evaluation of a New Backtrack Free Path Planning Algorithm for Manipulators," International IEEJ Trans. EIS, Vol. 128, No. 8, pp. 1293-1302, 2008
5. Jaime Gallardo-Alvarado, Carlos R. Aguilar-Najera, Luis Casique-Rosas, Jose' M. Rico-Martinez and **Md. Nazrul Islam** "Kinematics and Dynamics of 2(3-RPS) Manipulators by Means of Screw Theory and The Principle of Virtual Work," International Journal Mechanism and Machine Theory, Vol. 43, pp. 1281-1294, 2008
6. Jaime Gallardo-Alvarado, Ramon Rodriguez-Castro and **Md. Nazrul Islam** "Analytical Solution of The Forward Position Analysis of Parallel Manipulators That Generate 3-RS Structures," Int. Journal of Advanced Robotics, Vol. 22, pp. 215-234, 2008
7. M. K. Chowdhury and **M. N. Islam** " MHD Free Convection Flow of Visco-Elastic Fluid Past An Infinite Vertical Porous Plate," Int. J. Heat and Mass Transfer, Vol. 36, pp. 439-447, 2000

Conference Papers

- (1) Liyana 'Adilla Burhanuddin and **Md. Nazrul Islam** "Collision Avoidance Path Planning Algorithm for Manipulators based on Minimum Distance Technique", the 8th Postgraduate Annual Research Seminar (PARS'12) 27 to 29 November, 2012, Johor Bahru, Malaysia.
- (2) Fakhrul Syakirin Omar, **Md. Nazrul Islam** and Habibollah Haron, "Heuristic Modeling of Deformable Object using Node-based Structure with Mass-spring System" International Conference ICIDM 2012, 3-4 Decembe,, Langkawi Malaysia.

- (3) Liyana 'Adilla Burhanuddin and **Md. Nazrul Islam** "Collision Avoidance Path Planning Algorithm for Multi Manipulators by using Minimum Distance Technique", International Conference on Engineering and ICT (ICET 2012, 4 to 6 April), Melaka, Malaysia.
- (4) **Md. Nazrul Islam**, Shinsuke Tamura and Jaime Gallardo-Alvarado "Evaluation of a New Backtrack Free Path Planning Algorithm for Two Manipulators", International Conference on Research and Innovation in Information Systems – 2011 (ICRIIS'11) of IEEE, ISBN No. for IEEE of ICRIIS11 is 978-1-61284-294-3, Kuala Lumpur, Malaysia, November, 2011, (indexed by SCOPUS).
- (5) Shinsuke Tamura, Tomoya Murata, **Md. Nazrul Islam**, Tatsuro Yanase, and Syuji Taniguchi "A Path Planning Algorithm for Multi Manipulators", IEEE International Conference on Industrial Technology (ICIT), pp 1-6, Australia, Feb. 2009
- (6) Tomoya Murata, Shinsuke Tamura, Tatsuro Yanase, **Md. Nazrul Islam** and Kosuke Tsuciya "3-Dimensional Implementation of Path Planning Algorithm for Manipulators", Proceedings of University Student Exchange Programme, Xi'an, China, pp. 116-119, March, 2008
- (7) **Md. Nazrul Islam**, Tomoya Murata, Shinsuke Tamura, and Tatsuro Yanase, "Evaluation a New Path Planning Algorithm for Multi-Arm Manipulators," Asian Simulation Conference (JSST), Meiji University, Tokyo, pp. 133-137, Oct. 2006
- (8) Tomoya Murata, **Md. Nazrul Islam**, Shinsuke Tamura and Tatsuro Yanase "Performance Enhancement of a Path Planning Algorithm for Manipulators" pp. 211-214, 2006, JSST Conference (The Japan Society for Simulation Technology) June 10-12, 2006, Tokyo University, Tokyo, Japan
- (9) Shinsuke Tamura, Tatsuro Yanase, **Md. Nazrul Islam**, Takafumi Ito and Hikari Miyashita "A New Path Planning Algorithm for Manipulators," IEEE Int. Conf. on Systems, Man and Cybernetics, Hawaii, USA, pp. 2242-2247, Oct. 2005
- (10) **Md. Nazrul Islam** and Shinsuke Tamura "Evaluation of Path Planning Algorithm for Multi-Arm manipulator", Proceedings of University Student Exchange Programme (ACCU Int. Exchange Programme Under The UNESCO), Fukui, Japan, pp. P-39-40, March, 2006

PUBLICATION: BOOK CHAPTER

Year	Number	
2013	1	Md. Nazrul Islam , " Evaluation of a New Backtrack Free Path Planning Algorithm for Two Manipulators", Publisher: Universiti Teknologi Malaysia
2013	2	Liyana 'Adilla Burhanuddin and Md. Nazrul Islam "Collision Avoidance Path Planning Algorithm for Manipulators based on Minimum Distance Technique" Publisher: Universiti Teknologi Malaysia,

PUBLICATION: BOOK

Year	
2011	Razana Alwee, Md. Nazrul Islam , Azlan Mohd Zain, "Discrete Structure", Publisher: Universiti Teknologi Malaysia

REFEREES

(1) Prof. Mohamad Ishak bin Desa
Dept. of Computer Science
Faculty of Computing
University Technology Malaysia (UTM)
Johor Darul Takzim, Johor Bahru,
MALAYSIA
E-mail: mishak@utm.my
Tel: +60-7-5532012

(3) Prof. Jaime Gallardo-Alvardo
Department of Mechanical Engineering,
Instituto Tecnológico de Celaya,
38010, Celaya Gto., MEXICO
E-mail: gjaime@itc.mx (or)
jaime.gallardo@itcelaya.edu.mx
Tel: +52-461-611-7575

(2) Prof. Shinsuke Tamura
Department of Information Science
Faculty of Engineering, University of Fukui
3-9-1, Bunkyo Fukui 910-8507, JAPAN.
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Tel: +81-776-27-8043

(4) Prof. Habibollah Haron (HOD)
Dept. of Computer Science
Faculty of Computing
University Technology Malaysia (UTM)
Johor Darul Takzim, Johor Bahru,
MALAYSIA
E-mail: habib@utm.my
Tel: +60-7-5538771

TEACHING EXPERIENCE 1995– 2013

I am very much interested in joining the Kumamoto University to contribute towards the teaching and research in the department. I have been involved in Six Robotics related research projects and teaching in Computer Science Department, with the University Technology Malaysia, University of Verona (Italy), Tallinn University of Technology (Estonia), University of Fukui(Japan), Kingston University, London (UK) and Tohoku University, (Japan). I am very positive that with my academic abilities, international exposure and research/teaching experience, I can contribute towards teaching and research, particularly in the Department of Computer Science and Electrical Engineering at Kumamoto University. I have already taught in the below subjects.

University Technology Malaysia, Malaysia

Year	Semester	Name of Subjects	OMR (max score: 5.00)		
			My	Faculty	UTM
2012	II	Theory of Computer Science			
2012	II	Basic C Programming I Basic C			
2012	I	Object Oriented Programming	4.15	4.21	4.28
2012	I	Computational Mathematics	4.37	4.21	4.37
2011	II	Basic C Programming I Basic C	4.25	4.29	4.35
2011	II	Discrete Structures	4.37	4.21	4.37
2011	I	Programming Technique II C++	4.24	4.28	4.34

University of Fukui, Japan

Year	Semester	Name of Subjects
2006	April-September	System Software, Advanced
2005-06	October-March	Reliable Systems
2004	April-September	Advanced Information Base System
2003-04	October-March	Programming Technique II C++
2003	April-September	JAVA Programming

Stamford University, Dhaka, Bangladesh

Year	Name of Subjects
Oct.1997 – Aug. 2001	Discrete Structures, Computational Mathematics, Operations Research, JAVA Programming, FORTRAN, Fluid Mechanics, Linear Algebra, Vector Analysis, Complex Variable, Differential Geometry, Introduction to Calculus, Integral Calculus, Differential Calculus, Differential Equation, Partial Differential Equation,

Mathematical Method, Laplace Transform, Fourier analysis, Discrete Mathematics, Numerical Analysis, Fluid Dynamics.

Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh

Year	Name of Subjects
Mar.1995 - Sep.1997	Mathematical Method, Laplace Transform, Fourier analysis, Special Function & Integral Transforms, Similarity Analysis, Quantum Mechanics

I am able to teach on the below subjects also

Computer Science Theory, Robotics, Numerical Methods, Probability and Statistics, Modeling and Simulation, Programming III, Programming II, Programming I, Object Oriented Programming, Mathematics for Computing, Probability Theory, Object Oriented Programming, Computational Mathematics, Basic C Programming I Basic C, Programming Technique II C++, Discrete Structures, Java, Operations Research, FORTRAN, Fluid Mechanics, Linear Algebra, Vector Analysis, Complex Variable, Differential Geometry, Introduction to Calculus, Integral Calculus, Differential Calculus, Differential Equation, Partial Differential Equation, Mathematical Method, Laplace Transform, Fourier analysis, Discrete Mathematics, Numerical Analysis, Fluid Dynamics, Similarity Analysis, Quantum Mechanics, Statistical Data Analysis, Quality Control, General Mathematics, Algorithms and Heuristics, Fundamentals of Computing, Discrete Structures, Object-Oriented Analysis and Design. Computational Mathematics, Similarity Analysis, Quantum Mechanics, Statistical Data Analysis, Quality Control, Modeling and Simulation, Mathematics for Computing, Probability Theory, General Mathematics, Algorithms and Heuristics, Fundamentals of Computing, Discrete Structures, Object-Oriented Analysis and Design.

RESEARCH INTERESTS

Path Planning & Motion Planning Algorithm for Multi-Arms Multi-Manipulators/Robotics, Assistive Robotics, Human-Robot Interaction Modeling Coordinated Trajectory Planning of Two-Armed Robot's Manipulators, Collision Detection Algorithm in Deformable Environment for Medical Robot and Kinematics & Dynamics of Parallel Manipulators.

Details Explanation of Two Ongoing Research Projects:

(1) Collision Detection Algorithm in Deformable Environment for Medical Robot

In this research the problem of computing a rigid path planning in a populated deformable environment is address. The problem arise in Minimally Invasive Robotic Surgery (MIRS) from the needs to touch a point of interest inside the abdomen avoiding the soft tissue damage of the other organs. The abdomen is a very populated environment and it is not possible to apply classical technique of obstacle avoidance because the solution without collision is not always feasible. In order to have a convergent algorithm with at least one possible solution we have to relax the constraints and allow collision under a specific tissues threshold. Moreover the forces asserted from the environment on the probe are summed and minimized in order to obtain the most comfortable path for a surgeon that has to drive the probe. Therefore, in this research a new approach for path planning in a deformable environment will implement and tests. We will apply an optimal strategy to compute the path for a rigid body considering possible collision and penetration with obstacles, which will describe by a penetration function. In this research, we describe the approach and after evaluates the approach we will report on the early stage results.

A common robotic task is to plan a robot path planning from an initial configuration to a desired configuration. In its standard form, the solution of the motion planning problem requires the computation of a collision free path for a moving body between start and goal position. Depending on the free path, or one that provides the minimum (or close to minimum) overall cost, where the cost of a path may be a function of several factors. The most common factor to be minimized are time for traversal risk, stealth, and visibility. Several approaches exist for generating such paths, and in the following some of them are reviewed.

In this research, we are interested in motion planning in very populated environments in which objects can deform and under a penetration threshold they don't get damaged. This implies that environment object are constrained and that their reaction forces always blance the forces exerted by the moving body during its contacts with the objects.

Motion planning is normally studied in robotics to plan the motion of robot arms and robotics vehicles. Both devices are typically rigid, and move in a rigid environment. Inrecent years motion planning has been increasingly used in virtual environments and games[i], where deformation need also to be taken into account. One difficulty facing motion planning with deformable objects is having a (deformation) model that accurately represents the object physical properties, while preserving the efficiency of the planner. In fact, a planner that uses a physically correct deformation model can be very slow [ii] and a planner that uses only geometric deformations can compute unnatural motions[iii].

In fact, many situations arise where the environment consists of deformable objects. Our research is motivated by the possible application of motion planning to surgery, where the environment is the patient's organs and the robot is a surgical instrument.

In particular, our scenario is Minimally Invasive Robotic Surgery (MIRS), where small incision

are used to introduce special instruments with a long rod transmission mechanism through a cannula into the body of the patient, and covers all surgery with small incision and endoscopes like thorascopy, arthroscopy, laparoscopy, pelviscopy, angioscopy. Although MIRS fastens the rehabilitation of the patients, it also has some disadvantages. In open surgery the surgeon has more space and freedom to move in a large operation area. With MIRS, the operation area is smaller and the freedom to move the operation tool decreases with the use of an endoscopy. Laparoscopic tools are long and have only for degrees of freedom. Because of the long instruments, the operative situation is less ergonomic for the surgeon. Another disadvantage is the loss of visibility for surgeons. There is also a loss of tactile sensation and the contact sensation with the long endoscopic tools is totally different than in open surgery. This makes very hard to choose and perform without indication a proper path.

In this research we present a framework to obtain the most comfortable path for a surgeon that has to derive a probe; such path has collision and penetrations, because the obstacles are unavoidable in this environment. We represent the obstacles with a deformable model and compute an optimal path that accounts for number and type of collisions. The planning algorithm is based on the minimization of the penetration of the tool (a rigid object) in the soft obstacles, while moving. The goal here is not to compute the Penetration Depth of a collision, but to use penetration as a path penalty in the environment.

REFERENCES

- [i] Fakhru Syakirin Omar, **Md. Nazrul Islam** and Habibollah Haron, "Heuristic Modeling of Deformable Object using Node-based Structure with Mass-spring System" Under review for publish in International of Graphical Models(June 2012).
- [ii] M. Teschner and S. Kimmmerle, "Collision Detection for Deformable Objects," Computer Graphics, vol 24, No. 1, pp. 61-81, 2005
- [iii] S. Rodriguez, J. M. Lien and N. M.M Amato, "Planning motion in completely deformable environments," IEEE Int. Conf. Robot. Autom. (ICRA), 2006
- [vi] B. Heidelberger, M. Teschner, R. Keiser and M. Gross, "Consistent penetration depth estimation for deformable collision response," Vision Modeling, Visualization, 2004.

(2) Path Planning Planning Algorithm for Multi-Arms Multi-Manipulators/Robotics

The objective of my future research is to establish an efficient algorithm for planning paths of multi manipulators that cooperate with each other to perform complicated tasks in 2-dimensional and 3-dimensional environment. In the algorithm, multiple manipulators are considered as a single composite one. Therefore, the composite manipulator includes all arms of the individual manipulators. In my PhD, I developed new path planning algorithm BFA (Backtrack Free path planning Algorithm) enables the efficiency generation of paths of this composite manipulator with extremely many arms. The algorithm is backtrack free and resolution complete. Computation volume of the algorithm is proportional to the total number of arms included in the composite manipulator. An additional advantage of this algorithm is that paths of individual manipulators can be calculated completely in parallel.

Path planning is a process to find paths that bring initial attitudes of manipulators to their goal attitudes while avoiding collision with obstacles. Because of the paradigm change from low variety high volume to high variety low volume production, the efficiency of the manipulator path planning is becoming more and more important. Namely, in environments of high variety low volume production, machine layout is changed more frequently; therefore path planning must be completed quickly, and neither of manual planning and existing planning methods satisfy requirements in high variety low volume production paradigm. High variety low volume production also highlights the importance of cooperation among manipulators. Manipulation tasks required for manufacturing highly sophisticated products cannot be easily accomplished by single ones. But the difficulty can be reduced drastically by the cooperation of multi

manipulators. Results of this research enable efficient high variety low volume production by supplying ways for quickly introducing cooperating manipulators into changing manufacturing environments. Path planning algorithms for multi manipulators can be classified into two kinds, exact and heuristic algorithms, and because it is believed that the computation volume increases exponentially with the number of arms that constitute manipulators, currently used algorithms are based on heuristics [i]. However, heuristic algorithms do not ensure the finding of paths even they exist. Also they consume much time in several cases because they include many backtracks, and these facts prevent them from being applied to real-time systems especially in automated environments. To overcome these difficulties, recently a fast path-planning algorithm has been developed, which searches collision free paths for individual arms sequentially without backtracks (consequently the computation volume increases linearly with the number of arms). The above algorithm exploits the serial structure of manipulator arms and decomposes the N dimensional problem into N numbers of 1 dimensional problem. Also backtracks occurring in this decomposition are removed by making m copies of points where the moving areas of arms at them are divided into m connected sets of points. Namely, assumption [A] enables to prove the correctness of the necessary and sufficient condition of collision free path existence and the sequential path generation processes. Here assumption [A] is that individual arms can change their attitudes from X to Y at given positions when X and Y are feasible [ii, iii]. This research evaluates the possibility of this algorithm, and enhances and extends it so that it can be applied to the path planning for multi manipulators, in order to make the path planning be applicable to real time and automated applications in high variety low volume production.

In this context, the research issues are:

- algorithm evaluation: computation time and memory space are evaluated by developing experimental programs. also the frequencies of exceptional cases that require specific procedures such as collision avoidance of arms themselves are evaluated.
- algorithm enhancement: procedures corresponding to the above exceptional cases are improved to make algorithms more efficient, i.e. to decrease computation time and required memory space.
- path planning algorithm development for multi manipulators: path planning algorithm for multi manipulators are developed and their performances are evaluated. these algorithms enable cooperative behaviors of multi manipulators e.g. path generation that maintain relative attitudes of multi manipulators so that they can convey given work pieces while avoiding collisions.

My research interests are robotics, path and motion planning methods for multi-arms manipulators, and kinematics and dynamics of parallel manipulators. I also like to develop path planning algorithm for multi-arms manipulators with end arm locus and attitude constraints. It is an extension of the basic path planning algorithm and is particularly appropriate for multi-arm manipulators. The objectives of these constraints are that the last arm can move, for example, horizontally or vertically on the workspace. There are many potential application is a manipulator arm moving/transporting a glass of water which should keep the glass vertically up all the time. In some other applications, the last arm may be constrained to move in a plane or workspace. While several works have considered specific forms of constraints, the problem with general last arm constraints has not been addressed in previous works. Applications such as welding require the last arm to move along a given last arm locus or path. The maximum generalization of this idea is obtained when several arms should cooperate. Solving this general problem has applications to the generation of collision-free paths for closed kinematic loops,

thus including path planning for parallel robots.

References

- [i] Liyana ‘Adilla Burhanuddin and **Md. Nazrul Islam** “Collision Avoidance Path Planning Algorithm for Multi Manipulators by using Minimum Distance Technique”, International Conference on Engineering and ICT (ICET 2012, 4 to 6 April), Melaka, Malaysia.
- [ii] **Md. Nazrul Islam**, Shinsuke Tamura and Jaime Gallardo-Alvarado “Evaluation of a New Backtrack Free Path Planning Algorithm for Two Manipulators”, International Conference on Research and Innovation in Information Systems – 2011 (ICRIIS’11) of IEEE, ISBN no for IEEE of ICRIIS11 is 978-1-61284-294-3, Kuala Lumpur, Malaysia, November, 2011.
- [iii] S Tamura, T. Yanase, **M. N. Islam**, T. Ito and H. Miyashita "A New Path Planning Algorithm for Manipulators," IEEE Int. Conf. on Systems, Man and Cybernetics, Hawaii, USA, pp. 2242-2247, 2005.
- [vi] **M. N. Islam**, S. Tamura, T. Murata and T. Yanase, “Evaluation of a New Backtrack Free Path Planning Algorithm for Manipulators," accepted for publication to the International IEEEJ Trans. EIS, (7th April, 2008).

RESEARCH EXPERIENCES/GRANTS

- | | | |
|---|--------------------|--|
| 1 | Name of University | University Technology Malaysia (UTM) |
| | Title | Evaluation of a Path Planning Algorithm for Robotics Manipulators in 3-Dimensional Environment |
| | Duration | April 2011 – Mac 2012 |
| | Sponsor/RM | UTM/GUP/ RM 40,000.00 |
| | Designation | Project Leader |
| 2 | Name of University | University Technology Malaysia (UTM) |
| | Title | Minimum Collision Allow Path Planning in a Deformable Environments |
| | Duration | November 2011 – October 2012 |
| | Sponsor/RM | UTM/GUP/ RM 30,000.00 |
| | Designation | Project Leader |
| 3 | Name of University | Tallinn University of Technology (TTU), Estonia |
| | Title | Assistive Robotics, Human-Robot Interaction Modeling & Coordinated Trajectory Planning Of Two-Armed Robot’s Manipulators |
| | Duration | Oct.2009- Dec.2010 |
| | Sponsor/EURO | European Union (EU) Project / 21,000 EURO |
| | Designation | Project Member |
| 4 | Name of University | University of Verona, Italy |
| | Title | Robotics Motion Planning Algorithms in Deformable Environments (Medical Robotics) |

	Duration	Oct.2008 - Sep.2009
	Sponsor/EURO	European Union (EU) Project/ 18,000 EURO
	Designation	Project Member
5	Name of University	University of Fukui. Japan
	Title	Path Planning Algorithm for Multi-Arms Manipulators
	Duration	Jan.2003 - Sep.2008
	Sponsor/Yen	Japanese Government (Monbukagakusho) Scholarship program/ 12,0000 Yen (Per-Month)
	Designation	Project Member
6	Name of University	Kingston University(KU), London, UK
	Title	Large Eddy Simulation of Impinging Jet Flows
	Duration	Feb.2002 -Sep.200
	Sponsor/British Pound	Overseas Research Students Awards, KU/830GBP(Per month)
	Designation	Project Member
7	Name of University	Tohoku University, Sendai, Japan
	Title	Numerical Simulation of Blood Flow
	Duration	Aug.2001 -Feb.2002
	Sponsor/Yen	Japanese Government (Monbukagakusho) Scholarship program/ 10,0000 Yen (Per-Month)
	Designation	Project Member
7	Name of University	Bangladesh University of Engineering and Technology (BUET)
	Title	<u>MHD Free Convection Flow of Visco-Elastic Fluid Past on an Infinite Vertical Porous Plate</u>
	Duration	March.1995 –Dec. 1998
	Sponsor/Taka	BUET/5000 TK
	Designation	Project Member