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RESEARCH: ACCOMPLISHMENTS AND GOALS

My Philosophy of Life
 While there is a will there is a way

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Synopsis — Well-equipped laboratory, strong and committed research team and networking with international groups has resulted in excellence in research, impacting aerospace, health-care and security technologies as well as benefiting local community. Notable ideas presented are the fourth law of thermodynamics, the sixth paradigm of physics, cross lattice (generalization of reciprocal lattice— condensed matter physics), intelligent power (generalization of soft power and smart power — international relations), modeling money (flow) as a substance-like quantity (mathematical economics), edge-based moiré (combination of moiré fringe topography and edge-based algorithm — computer vision), air-spacecraft of the third millennium (aeronautics and astronautics), mathematical definition of brain death (mathematical neuroscience) and anthromathematics.

RESEARCH INSTRUMENTS Moiré-Generation System Raster-Generation System Wall-Mounted-Height-Measurement System	SUPPORTING INSTRUMENTS Beam Scale Bathroom Scale Digital Scale Z-5 Digital Camera
RESEARCH FUNDING Dean (Science) Research Grant DFS/2009	SOFTWARES Growth-and-Obesity Profile Moiré Data Analysis Raster data Analysis

Fig. 1. Research set-up of our group

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- Philosophy** To capitalize on the strengths of mathematics, having the power of generalization and the power of application, to formulate and to propose “smart” solutions, which enhance man's quality of life by converting them into commercial products, services and processes, which are comfortable, economical, environmentally friendly and safe.
- Methodology** A Nobel laureate was asked, "What is the key to your success?" He replied, "I know what I am doing, in depth, and know a little bit about other disciplines". This strategy of complete knowledge of the problem at hand and knowledge of the associated fields is to be applied to bring out efficient, elegant and innovative solutions to problems challenging the mankind in the third millennium, using the techniques of mathematics. Modeling of system, environment and sources of error to be done using mathematical tools, fine-tuning to be done through simulations and test runs, followed by validation through field trials.
- Accomplishments** 120 papers (108 as solo/first/corresponding author) in biomathematics, astrodynamics, relativity, physical mathematics and algebra, some of them published in Biological Cybernetics [Impact Factor = 1.667], Journal of Biological Physics [Impact Factor = 1.373] as well as Matrix and Tensor Quarterly.
- Mathematical models of the human brain (involving matrices of the order of $10^{16} \times 10^{16}$), which could not be processed by the fastest supercomputers available in the world), the human spinal column (presented the idea of treating the spinal column as a 3-dimensional problem, formulated 3-D static and dynamic models), the human heart (introduced cardiac-coördinate mesh, treated heart as a system of standing waves), the growth of children (developed methods to generate detailed growth pro-files) and the planetary orbits (introduced the elliptic-astrodynamical-coördinate mesh, formulated equation of motion in this mesh) were developed. 3-D optical imaging and image processing (moiré fringe topography, rasterstereography) systems were set up and studied to generate 3-D coördinates and curvatures of a test object. In particular, postures and gaits of children were studied and procedures devised to simultaneously project moiré and raster grids on a moving object and decode information about 3-D coördinates and curvatures through selective optical filtering. In addition, moiré fringe topography was combined with the edge-based algorithm to study 3-D motion. Normally, the edge-based algorithm would be able to handle only 2-D motion.
- Other important accomplishments include proposing an identification system employing dynamic-biometric patterns, defining determinant of a general tensor, proposing extended symmetries in special relativity, studying behavior of massive particles near velocity of light, deriving Dirac's relativistic equation starting from the energy operator in rest frame, formulating control laws (the extended-cross-product steering, the normal-component-cross-product steering, the dot-product steering, the normal-component-dot-product steering, the ellipse-orientation steering), devising guidance schemes (the Lambert scheme with correction for cross-range error, the inverse-Lambert scheme, the inverse-Q system, the multi-stage-Q system) and applying concepts of precedence and influence graphs to clinical medicine. In the area of foundations of mathematical physics, mathematical formulation of sixth paradigm of physics was given.
- Impact on Technologies** **Health-Care Industry**
- The model of growth of children could predict a boy's or a girl's adult height and adult weight as well as suggest control measures to achieve the desired height and weight at a tender age. Using the ideas of mathematics and physics, efficient and effective techniques for determination of height and weight are developed, tested and imple-

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Impact on Technologies (continued) mented as part of the NGDS Pilot Project <<http://ngds-ku.org>>. 3-D models of the spinal column have given new dimensions to detection, documentation, follow up and treatment of scoliosis. Simultaneous recording using moiré fringe topography and rasterstereography could be used in kinesiology and biomechanics to assess movement of spine. They could, also, be used to improve gymnastic performance. Edge-based moiré could be used to quantify movement of lips with applications in speech analysis.

Aerospace Industry

The new control laws proposed and the guidance schemes developed could be used to design efficient and effective space missions as well as passenger aircrafts traveling partly in space in the ballistic orbits. Technological benefits include:

- a) Reduction in travel time— *comfort*
- b) Reduction in fuel consumption (most of the flight shall be in the ballistic phase, consuming no fuel), which would be passed on to customer as reduction in ticket price— *economical/environmentally friendly*
- c) Reduction in engine noise (most of the flight shall be in the ballistic phase, during which the engines would not be operating)— *comfort*
- d) Absence of turbulence (most of the flight shall be in the ballistic phase in space)— *comfort*
- e) Since engines are not required in the ballistic phase, there would be a reduced risk of engine failure — *safety*

Security Technologies

The multi-level screening system, described in my paper “Pattern Recognition using Moiré Fringe Topography and Rasterstereography”, may form the basis of a highly specific, card-less identification system, employing biometric identifiers, which could be used in place of identity cards or passports. The explosive and drug trace-detection system, proposed in my paper “An Airport-Passenger-Screening System based on Emitted IR and Thermal Radiation”, may be used in place of security gates and full-body, backscatter-X-ray scanners at the airports.

Honors Research-Productivity Allowance awarded by Higher Education Commission (2003), nominated for the King Faisal International Prize in Science (Mathematics) 2010 by University of Karachi, referee of Clinical Biomechanics (Elsavir) [Impact Factor = 2.036], Optics and Laser Technology (Elsavir) [Impact Factor = 1.616], Journal of Industrial Textiles [Impact factor = 0.811], Proceedings of the Pakistan Academy of Sciences and Journal of Scientific and Industrial Research (published by PCSIR), 69 colloquia, guest lectures, presentations and seminars given. He was keynote speaker in 2 conferences, invited speaker in 10 conferences, session chair in 8 conferences, panelist (panel discussion) in 2 conferences as well as chief guest in the Sindh Educational Conference (2009). Delivered many memorial lectures, the last one *Sheikh Ansar Husain Memorial Lecture* for the National Conference on Physics and the World of Today in the memory of Sheikh Ansar Husain on December 21, 2011.

Goals During the coming years I would like to continue working in the areas of mathematical modeling, mathematical physics (devising methods to deal with nonlinear systems) and control theory (formulating new control laws), with applications in the fields of biomathematics, bioinformatics, astrodynamics, economics and finance. Further, I would try to establish liaison with local industry, in order to get adequate funding for the projects and be able to understand needs of the society we are a part of.

Research Policy Research-Project-Evaluation Committee, Dean, Faculty of Sciences, FY 2007-present, *Member*

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Representative Space Medicine**Papers** *EEG in Weightlessness: A Theoretical Estimate*

Ahmed SN, **KAMAL SA**, Siddiqui KA, Husain SA, Naeem M, Karachi University Journal of Science, 25(1), 1997, 19-24 (corresponding author) <<http://www.ngds-ku.org/jourabst0.htm#J20>> (no spaces in the address)

Security Technologies*Pattern Recognition using Moiré Fringe Topography and Rasterstereography*

KAMAL SA, Proceedings of the International Symposium on Biometrics and Security Technologies (IEEE ISBAST 2008), Bahria University, Islamabad, Pakistan, 2008, pp 1-7 <<http://www.ngds-ku.org/pub/confabst.htm#C68>>

An Airport Passenger Screening System based on Emitted IR and Thermal Radiation

KAMAL SA, the Fifth Symposium on Computational Complexities, Innovations and Solutions, COMSATS Institute of Information Technology, Abbotabad, KP, Pakistan, 2011, abstract#24, p 21 <<http://www.ngds-ku.org/pub/confabstA.htm#C81>>

Control Theory*Ellipse-Orientation Steering: A Control Law for Spacecrafts and Satellite-Launch Vehicles*

KAMAL SA, Space Science and Challenges of the Twenty-First Century, ISPA-SUPARCO Collaborative Seminar, University of Karachi, 2005 (invited lecture) <<http://www.ngds-ku.org/pub/confabst.htm#C64>>

Incompleteness of Cross-Product Steering and a Mathematical Formulation of Extended-Cross-Product Steering

KAMAL SA, Proceedings of the First International Bhurban Conference on Applied Sciences and Technologies (IBCAST 2002), Volume 1, Advanced Materials, Computational Fluid Dynamics and Control Engineering, Edited by Hoorani HR, Munir A, Samar R, Zahir S, National Center for Physics, Bhurban, NWFP, Pakistan, 2003, pp 167-177 <<http://www.ngds-ku.org/pub/confabst.htm#C56>>

Dot-Product Steering: A New Control Law for Satellites and Spacecrafts

KAMAL SA, Proceedings of the First International Bhurban Conference on Applied Sciences and Technologies (IBCAST 2002), Volume 1, Advanced Materials, Computational Fluid Dynamics and Control Engineering, Edited by Hoorani HR, Munir A, Samar R, Zahir S, National Center for Physics, Bhurban, NWFP, Pakistan, 2003, pp 178-184 <<http://www.ngds-ku.org/pub/confabst.htm#C55>>

Guidance Schemes*The Multi-Stage Lambert Scheme for Steering a Satellite-Launch Vehicle (SLV)*

KAMAL SA, Proceedings of the Twelfth IEEE International Multitopic Conference (IEEE INMIC 2008), Edited by Anis MK, Khan MK, Zaidi SJH, Bahria University, Karachi, Pakistan, 2008, pp 294-300 (invited paper) <<http://www.ngds-ku.org/pub/confabst.htm#C72>> (no spaces in the address)

Incorporating Cross-Range Error in the Lambert Scheme

KAMAL SA, Proceedings of the Tenth National Aeronautical Conference, Edited by Sheikh SR, Khan AM, College of Aeronautical Engineering, Pakistan Air Force Academy, Risalpur (Pakistan), 2006, pp 255-263 <<http://www.ngds-ku.org/pub/confabst.htm#C67>> (no spaces in the address)

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Representative Papers *The Multi-Stage-Q System and the Inverse-Q System for Possible Application in Satellite-Launch Vehicle*

(continued) **KAMAL SA**, Mirza A, Proceedings of the Fourth International Bhurban Conference on Applied Sciences and Technologies (IBCAST 2005), Volume 3, Control and Simulation, Edited by Hussain SI, Munir A, Kayani J, Samar R, Khan MA, National Center for Physics, Bhurban, KP, Pakistan, 2006, pp 27-33 <<http://www.ngds-ku.org/pub/onfabst.htm#C66>> (no spaces in the address)

Three-Dimensional-Optical Imaging and Image Processing

3-D Optical Imaging and Image Processing (Biomedical Applications)

KAMAL SA, Proceedings of the International Workshop on Recent Advances in Computer Vision, Edited by Laghari JR, Naqvi AA, Rajput AQ, Sangi NA, Shah MA, SZABIST, Karachi, Pakistan, 1998, pp 86-95 <<http://www.ngds-ku.org/pub/confabst.htm#C66>> (no spaces in the address)

Combination of Moiré Contours and Edge-Based Algorithm to Study Motion in the Sagittal Plane

KAMAL SA, Karachi University Journal of Science, 24(2), 1996, 53-60 <<http://www.ngds-ku.org/pub/jourabst0.htm#J17>> (no spaces in the address)

Gait Analysis Using Moiré Fringe Topography and Rasterstereography (Simultaneous Recording)

KAMAL SA, Choudhry AS, Siddiqui YA, Karachi University Journal of Science, 24(2), 1996, 7-18 <<http://www.ngds-ku.org/pub/jourabst0.htm#J16>>

Modeling Growth of Children

Growth-and-Obesity Profiles of Children of Karachi using Box-Interpolation Method

KAMAL SA, Jamil N, Khan SA, International Journal of Biology and Biotechnology, 8(1), 2011, 87-96 <<http://www.ngds-ku.org/pub/jourabst.htm#J29>>

An Investigation of Growth Profiles of the Pakistani Children

KAMAL SA, Firdous S, Alam SJ, International Journal of Biology and Biotechnology, 1(4), 2004, 709-717 <<http://www.ngds-ku.org/pub/jourabst.htm#J26>>

Modeling Human Brain

The Covariant-Generalized-Coupling Model of Global-Electrocortical Activity

KAMAL SA, Siddiqui KA, Karachi University Journal of Science, 25(1), 1997, 29-39 <<http://www.ngds-ku.org/pub/jourabst0.htm#J19>>

Group Structure of a Covariant Model of Global-Electrocortical Activity

Siddiqui KA, **KAMAL SA**, Husain SA, Khan NU, Karachi University Journal of Science, 21(1&2), 1993, 35-38 <<http://www.ngds-ku.org/pub/jourabst0.htm#J14>>

Spacetime Representation of Global-Electrocortical Activity

KAMAL SA, Siddiqui KA, Husain SA, Biological Cybernetics, 60, 1989, 307-309 <<http://www.ngds-ku.org/pub/jourabst1.htm#J08>>

Modeling Human Spinal Column

A 3-D-Static Model of the Human Spinal Column

KAMAL SA, Karachi University Journal of Science, 24(1), 1996, 29-34 <<http://www.ngds-ku.org/pub/jourabst0.htm#J18>> (no spaces in the address)

3-D-Dynamic Modeling of the Human Spinal Column

KAMAL SA, the Twenty-First International Nathiagali Summer College on Physics and Contemporary Needs, Nathiagali, NWFP, Pakistan, 1996 <<http://www.ngds-ku.org/pub/confabst0.htm#C42>> (no spaces in the address)

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- Representative Papers (continued)**
- Modeling Human Heart**
The Human Heart as a System of Standing Waves
KAMAL SA, Siddiqui KA, Karachi University Journal of Science, 30(1&2), 2002, 55-63
 <<http://www.ngds-ku.org/pub/jourabst.htm#J25>>
- Sports Sciences and Technologies**
Role of Mathematics in the Sports Sciences and Technologies
KAMAL SA, the Thirty-Fifth All Pakistan Science Conference, University of Karachi, Karachi, Pakistan, 2008, abstract # 72 <<http://www.ngds-ku.org/pub/confabst.htm#C71>> (no spaces in the address)
- Financial Mathematics**
Intelligent ledger Balance Transformations
KAMAL SA, the Sixth Symposium on Computational Complexities, Innovations and Solutions, COMSATS Institute of Information Technology, Abbotabad, KP, Pakistan, 2011, abstract#2, pp 14, 15 (the Islamuddin memorial lecture) <<http://www.ngds-ku.org/pub/confabstA.htm#C84>> (no spaces in the address)
- Mathematical Physics**
Avoiding Infinities from the Lorentz and the Poincaré Transformations
KAMAL SA, the Fourth Symposium on Computational Complexities, Innovations and Solutions, COMSATS Institute of Information Technology, Abbotabad, KP, Pakistan, 2009, p 16 (invited paper) <<http://www.ngds-ku.org/pub/confabst.htm#C75>>
The Sixth Paradigm of Physics
KAMAL SA, Siddiqui KA, Naseeruddin, Karachi University Journal of Science, 28(2), 2000, 11-16 <<http://www.ngds-ku.org/pub/jourabst.htm#J24>>
A Dimensionless-Reciprocal Lattice
KAMAL SA, Husain SA, Karachi University Journal of Science, 16(1&2), 1988, 23-27
 <<http://www.ngds-ku.org/pub/jourabst1.htm#J07>>
Determinant of a General Tensor
KAMAL SA, Matrix and Tensor Quarterly (UK), 31(3), 1981, 64-66 <<http://www.ngds-ku.org/pub/jourabst1.htm#J03>> (no spaces in the address)
- Training Programs for Future Researchers**
- Research Methodology I*
 Graduate Studies Course (for MS/PhD students), Faculty of Sciences, University of Karachi, First Semester 2009 (Course Faculty) <http://www.ngds-ku.org/DFS/ASR701_09.pdf> (no spaces in the address)
- Research Methodology II*
 Graduate Studies Course (for MPhil/PhD students), Faculty of Sciences, University of Karachi, First Semester 2009 (Course Coördinator) <<http://www.ngds-ku.org/DFS/ASR702.htm>> (no spaces in the address)
- Technical Aspects of Preparing a Research Proposal*
 Presentation, Workshop on Preparing Research Proposals, Office of Dean, Faculty of Sciences, University of Karachi, August 16, 2008 (Coördinator of the Workshop) <<http://www.ngds-ku.org/DFS/DFS01.htm>> (no spaces in the address)
- Research Methodology*
 Graduate Studies Course (for MPhil/PhD students), Faculty of Arts, University of Karachi, November 21-24, 2007 (Course Faculty)
- Research-Proposal Writing*
 Research Seminar, Department of Mathematics, University of Karachi, February 11, 2006

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Motivating Programs for Future Researchers *The First Year Seminar Series*
Starting academic year 2011, the First Year Seminar Series was initiated by me, when I was Acting Chairman of Department of Mathematics to enlighten just-enrolled BS students and expose them to the exciting research in the field of mathematics (Program Convener)

The Undergraduate Student Research Participation Program
Students oriented towards research by requiring them to prepare proposals dealing with practical problems, employing mathematical techniques, one student from the Aga Khan University Medical College did his research elective, some students co-authored papers, 1988-present (Program Convener)

Talent-Farming Scheme
Summer School for BSc and MSc students, HEC Regional Center, Karachi, July 12-20, 2004 (Faculty)

The Early Talent Research Participation Program
A subproject of the NGDS Pilot Project
High-School Students are introduced to the ongoing research programs of University of Karachi, 2002-present (Program Convener) <http://www.ngds-ku.org/ngds_URL/subprojects.htm#ETRPP> (no spaces in the address)

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