

Research statement

Introduction: My research interests revolve around mechatronics engineering. Because of the highly and continuous demand from industry on this particular topic, I have decided to pick it as my main theme of research. Being as a mechatronics professor however is not an easy task as you will be required to know about many topics simultaneously as: control engineering, mechanical design, multi-body and nonlinear dynamics, finite element analysis, modelling and simulation, electromechanical systems, systems integration and others. These are making the mechatronics as a very challenging topic which has attracted me more to specialize. My particular interests are (1) nonlinear and multi-body dynamics, (2) linear and nonlinear finite element analysis, (3) design of electromechanical systems (4) computer aided design and engineering, and (5) intelligent and fuzzy control systems.

Research philosophy and methodology: My research methodology is to *build* an initial design layout using an appropriate software, e.g. ANSYS, simulating the proposed design and gathering data from simulation, *analyze* the data to have useful patterns of the design performance and efficiency, *validate* the simulated design experimentally, *optimizing* the system design using the developed simulation model, and finally correlating the optimized simulated model with the experimental one and *updating* the system design in case any necessity arose. I firmly believe that it is necessary to start a research problem by simulation to reduce the overall cost, and at the same time relying totally on the experimental data to give a final decision about the proposed design.

In my PhD dissertation, I began my research by building the entire model of using finite element software ANSYS 12.0. Then I analyzed the results and got a very good indication about the system components behaviour, afterwards, an optimization took place to optimize the system parameters and dimensions. In meanwhile, I was building a specialized test rigs to conduct the experimental part, and to validate my simulation data.

On the other hand, I believe in collaboration and the value of working as part of a team. In fact working as a part of team makes the research work way easier at the same time getting the benefit to learn from other senior researcher's experience. I am currently trying to establish a collaboration with many researchers and colleagues at different universities and institutes to create a network of researchers for aforementioned reason, and to produce a high quality of publications and research works. Such universities: Jordan University of Science and Technology-Jordan, Cork Institute of Technology-Ireland, Kuwait University-Kuwait, University of Jordan-Jordan, and Dublin City University-Ireland.

Past research

(1) Integrated electromagnetic micropump (MSc thesis)

In this research work a full dynamic modelling and simulation study, for a newly electromagnetic micropump concept, were introduced. An analytical model was developed firstly of microsolenoid and then validated it using finite element analysis. Afterwards, another dynamic model and simulation were developed of the entire micropump. The Matlab Simulink was used to simulate all models and FEMM package for finite element analysis. The results of the research work have been summarized in two journal articles.

(2) SISO optimized fuzzy model

This research work presented a methodology to develop an optimum fuzzy model of Single-Input-Single-Output (SISO) data. The proposed methodology was used to develop two models. The first one was using Mamdani as inference mechanism, and the second one was using Takagi-Sugeno inference mechanism. The Least Square Method (LSM) was employed to optimize the developed models. The

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research work was ended by testing the methodology on highly nonlinear data, and all has been summarized and described in one journal article.

(3) Protection of embedded systems for applications involving high loading rate mechanical forces (PhD dissertation):

The research described the development of a methodology to optimize the dimensions and mechanical properties of force-absorbing layers surrounding miniaturized embedded electronic modules subject to high mechanical compressive/impact forces and vibration. Such systems might be embedded specifically for measurement of mechanical forces, or for other measurement and monitoring purposes. While much has been published on the mechanical protection of electronic systems in larger-scale applications, where traditional mechanical shock absorbers and springs can be used to protect the electronics, little has been published on the mechanical protection of miniature electronic modules embedded in smart structures and materials where traditional methods of mechanical protection are not feasible. The application boundary parameters are small size (typically less than 1.0 cm³ for the embedded electronic module) and minimum cost. The generalized system concept used in this thesis is of module encapsulation in a multilayer of materials to act as mechanical buffer. The dissertation contributions were mainly in the following fields: finite element modelling of nonlinear materials, transient nonlinear finite element analysis of impact system, modelling and simulation of nonlinear materials impact, experimental mechanics, and optimization of a heterogeneous multi-layered structure for stress reduction purpose. In term of publications, up to now, six articles have been published already and two more are under reviewing, i.e. eight articles in total.

Current Research

(1) Computer aided design

I am currently working extensively on development of a parametric code for designing complex mechanical parts; parts include gears, shafts, springs ...etc. The code aims to design such parts with only few inputs from users which would accelerate building new mechanical systems significantly. This work is an industrial oriented one.

(2) Intelligent and fuzzy control

I am in process of developing a new concept of intelligent and fuzzy-based controllers. The concept deals mainly a with MIMO (multi-input-multi-output) system which overcomes on the issue of computation time of typical fuzzy controllers. No test vehicle has been chosen yet, however, multi-axis chassis of trucks is a potential candidate of my concept as well as unmanned vehicles.

Future Agenda: My future research career aims is to establish an integrated centre with name ICAD (Institute of Computer Aided Design), it includes three research groups. The first group takes care of computational modelling and simulation of nonlinear materials which is the backbone of the whole centre. The second research group takes care of employing intelligent and fuzzy tools to model highly nonlinear materials for designing purposes. And a third group which has inputs from the first two centres and employing the developed models, of materials, to design mechanical parts and structure for industrial partners. Having such integrated centre however is not an easy task, it requires recruiting at least 15 researchers in the final phase, i.e. a richly funding is a must which is my main duty as soon as I join. Two main incomes would be expected from my ICAD which are (1) a significant number of articles published yearly by its members, and (2) a generous endowment from industrial partners.