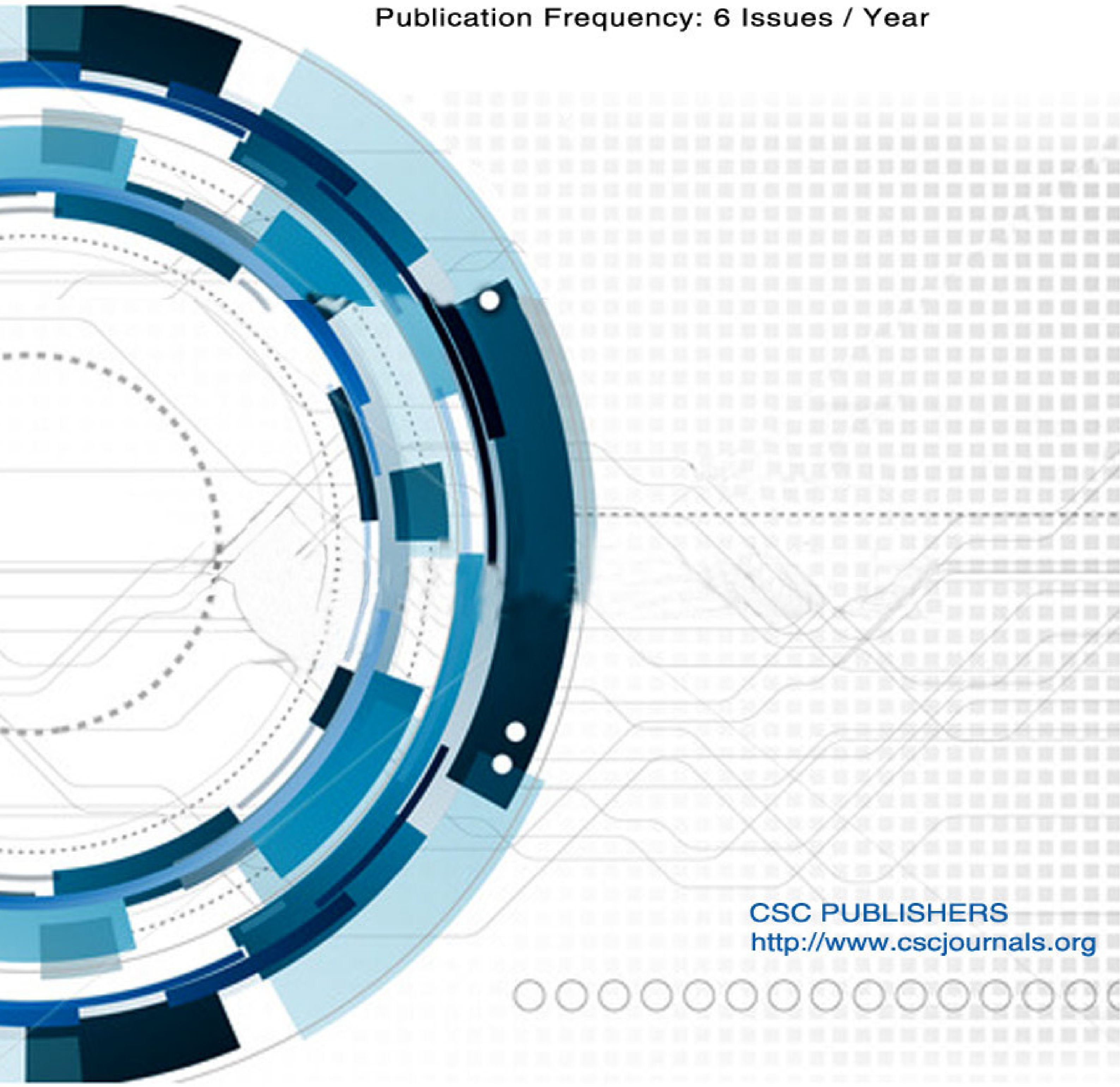
INTERNATIONAL JOURNAL OF ENGINEERING (IJE)

ISSN : 1985-2312

Volume 7 • Issue 3 • September 2013

Publication Frequency: 6 Issues / Year



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INTERNATIONAL JOURNAL OF ENGINEERING (IJE)

VOLUME 7, ISSUE 3, 2013

EDITED BY
DR. NABEEL TAHIR

ISSN (Online): 1985-2312

International Journal of Engineering is published both in traditional paper form and in Internet. This journal is published at the website http://www.cscjournals.org, maintained by Computer Science Journals (CSC Journals), Malaysia.

IJE Journal is a part of CSC Publishers
Computer Science Journals
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INTERNATIONAL JOURNAL OF ENGINEERING (IJE)

Book: Volume 7, Issue 3, September 2013
Publishing Date: 15-09-2013
ISSN (Online): 1985-2312

IJE Journal is a part of CSC Publishers
http://www.cscjournals.org

Published in Malaysia

Typesetting: Camera-ready by author, data conversation by CSC Publishing Services – CSC Journals, Malaysia

CSC Publishers, 2013

EDITORIAL PREFACE

This is the *Third* Issue of Volume *Seven* for International Journal of Engineering (IJE). The Journal is published bi-monthly, with papers being peer reviewed to high international standards. The International Journal of Engineering is not limited to a specific aspect of engineering but it is devoted to the publication of high quality papers on all division of engineering in general. IJE intends to disseminate knowledge in the various disciplines of the engineering field from theoretical, practical and analytical research to physical implications and theoretical or quantitative discussion intended for academic and industrial progress. In order to position IJE as one of the good journal on engineering sciences, a group of highly valuable scholars are serving on the editorial board. The International Editorial Board ensures that significant developments in engineering from around the world are reflected in the Journal. Some important topics covers by journal are nuclear engineering, mechanical engineering, computer engineering, electrical engineering, civil & structural engineering etc.

The initial efforts helped to shape the editorial policy and to sharpen the focus of the journal. Started with Volume 7, 2013, IJE appears with more focused issues. Besides normal publications, IJE intend to organized special issues on more focused topics. Each special issue will have a designated editor (editors) – either member of the editorial board or another recognized specialist in the respective field.

The coverage of the journal includes all new theoretical and experimental findings in the fields of engineering which enhance the knowledge of scientist, industrials, researchers and all those persons who are coupled with engineering field. IJE objective is to publish articles that are not only technically proficient but also contains information and ideas of fresh interest for International readership. IJE aims to handle submissions courteously and promptly. IJE objectives are to promote and extend the use of all methods in the principal disciplines of Engineering.

IJE editors understand that how much it is important for authors and researchers to have their work published with a minimum delay after submission of their papers. They also strongly believe that the direct communication between the editors and authors are important for the welfare, quality and wellbeing of the Journal and its readers. Therefore, all activities from paper submission to paper publication are controlled through electronic systems that include electronic submission, editorial panel and review system that ensures rapid decision with least delays in the publication processes.

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Vibration Analysis of Micro Scale Pipes Containing Internal Fluid Flow with Standing Beam Excited by Piezoelectric Material

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Abstract

In this paper, interaction between fluid and structure as a numerical simulation of flow through a two-dimensional micro channel with an embedded elastic structure is studied. The micro system vibration exigencies by applied magnetic field to the piezoelectric material of micro standing beam and motion of the wind system has been studied. The system includes a micro-channel and standing beam that is tied from bottom. First the eigenvalues of the system gain and therefore the resonance frequencies will be obtained. Finally with changing in initial and boundary conditions of system, the frequency response of system analyzed and with getting maximum frequency, it compared with the system resonance frequencies.

Keywords: Fluid Structure Interaction, Micro Channel, Micro-beam, Piezoelectric Material, Frequency Response.

1. INTRODUCTION

The purpose of this paper is getting to response of nonlinear equation for a micro beam with arbitrary condition in interaction with fluid flow aerodynamic force and the other forces induced by the magnetic field on the piezoelectric material.

Micro channels are usually integrated in micro systems, it is important to know the characteristics of the fluid flow in these micro channels for better design of various micro-flow devices. The characteristics of fluid flow and heat transfer in micro channels are remarkably different from those for conventional sized channels.

Interaction between an elastic structure and a fluid has been the subject of intensive investigations in recent years [1], [2], [3], [4]. Since analytical solutions are available only for very simple problems, numerical approaches, which can be formulated in time or frequency domain, have to be employed. Vonestorff et al. in [5] investigated the coupled fluid-structure systems subjected to dynamic loads using the finite element and boundary element methods. Similar method is used by Olson in [6] to analyze fluid-structure interaction. Many researchers have attempted to derive variational principles for different classes of the fluid-structure interaction problems.

Pinsky and Abboud in [7] proposed two mixed variational principles for transient and harmonic analyses of non-conservative coupled exterior fluid-structure interaction systems.

Kock and Olson [8] presented a finite element formulation directly derived from a variational indicator based on Hamilton's principle. Zeng et al. [9] developed an energy-based symmetric coupled finite element and boundary integral method which is valid for all frequencies. Seybert [10] employed Ritz vectors and eigenvectors along with a combination of finite element and boundary element methods to reduce the problem size.

Equations include non-permanent continuity equation, navier-stokes and differential equations describing the vibrations micro beem that must be solved couple. For solving system of equations COMSOL software is used with giving initial conditions and applied voltage to the system. In conventianal work the fluid convey in micro beam [11] and study vibration effect for micro beam [12]. But In this paper, standing micro beam actuated by piezoelectric will be analysis. In this paper interaction between air flow and a beam in the micro channel is analyzed. The length of micro channel is 300 μm and the height of that is 100 μm and a vertical structure is located 100µm away from the channel inlet, the beam width is 12.5 μm and height is 60 μm. The micro beam is made of 2 aluminum 300-H18 layer and between them is PZH-5H piezoelectric material that is indicated with quiet colour in Figure 1 And for more weigh and corresponding momentum a alloy of aluminum and copper indicate in the head of micro beam.

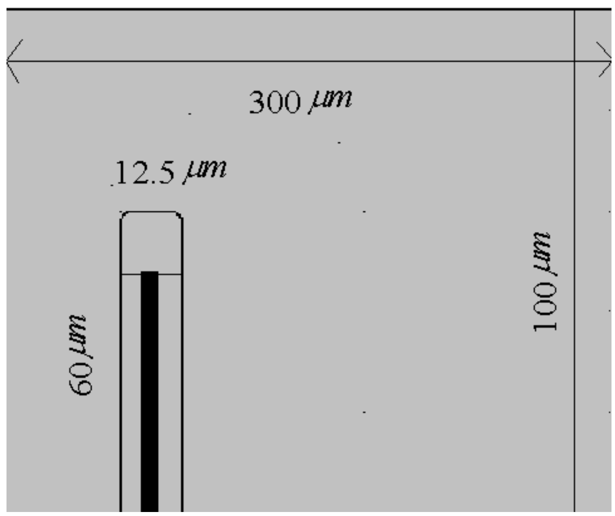

FIGURE 1: Figure of System.

In the Figure 1. Fluid flow come in from left side and goes out to right side. In equation 3 the fluid flow equation in indicated. The fluid in the channel has the property of air with a density of 1 kg/m3.

2. MATERIALS AND METHODS

COMSOL is used to analyze the fluid-structure interaction as it provides a strong coupling between the dynamics of fluids and the dynamics of structures. At each computational step, the fluid flow field and the structure evolve as a coupled system. The interaction forces are immediately accounted for and their resultant motions enforced in each step.

In this paper Flow field is solved in a continuously deforming geometry using the arbitrary Lagrangian-Eulerian (ALE) technique. The fluid flows in the channel from left to right. An obstacle, however, forces it into the narrower path in the upper portion of the channel, and a force resulting from the viscous drag and fluid pressure is imposed at the walls.

The ALE method handles the dynamics of the deforming geometry and the moving boundaries with a virtual moving grid. It computes new mesh coordinates on the channel area based on the movement of the boundaries of the structure. It reformulates the Navier-Stokes equations that solve the flow. The structural-mechanics portion of the model does not require the use of ALE, and it solves in a fixed coordinate system as usual. However, the strains computed are to be used for the computation of the deformed coordinates with ALE.

Following are the governing equations, which are solved using ALE technique:

$$\rho\frac{\partial u}{\partial t}-\nabla.[-pI+\eta(\nabla u+(\nabla u)^T)]+ \quad (1)$$

$$\rho((u-u_m).\nabla)u=F$$

$$-\nabla.u=0 \quad (2)$$

Where ρ is the fluid's density, $u=(u,v)$ is the velocity field of the flow, ρ is the fluid pressure, I is the unit diagonal matrix, and $F=(f_x,\ f_y)$ is the volume force affecting the fluid.

At the entrance the flow is fully developed with a parabolic velocity profile, but the flow amplitude changes with time. At first it increases rapidly, reaching its peak value at 0.215cm/s; thereafter the flow gradually decreases to its steady-state value of 5cm/s.

The centerline velocity u_{in} in the x-direction with the steady-state amplitude U is given as:

$$u_{in}=U.t^2/\sqrt{t^8-0.07t^2+0.00016} \quad (3)$$

Pressure is specified at the channel outlet. For all other boundaries, no-slip condition is imposed. However, on boundaries where the fluid forces the structure to deform, the no-slip condition means that the fluid moves with the velocity of the adjacent fluid-structure boundary [13].

Equations for this purpose include Mass conservation equation:

$$\frac{\partial\rho}{\partial t}+\nabla.\rho\tilde{\vec{V}}=0 \quad (4)$$

Navier - Stokes::Conservation of linear momentum equation is known as Newton's second law, which in fact represents the balance between the forces acting on a fluid element and its acceleration:

$$\rho\frac{D\tilde{\vec{V}}}{Dt}=\nabla.\tau_{ij} \quad (5)$$

In equation 5, stress tensor for a Newtonian fluid obtain by equation 6

$$\tau_{ij}=-\tilde{P}\delta_{ij}+\mu(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i})+\delta_{ij}\lambda\nabla.\tilde{\vec{V}} \quad (6)$$

And now the momentum equations in two-dimensional Cartesian coordinate can be obtained

$$\frac{\partial \tilde{u}}{\partial \tilde{t}} + \tilde{u}\frac{\partial \tilde{u}}{\partial \tilde{x}} + \tilde{v}\frac{\partial \tilde{u}}{\partial \tilde{y}} = -\frac{1}{\rho}\frac{\partial \tilde{P}}{\partial x} + \tilde{\mu}\left(\frac{\partial^2 \tilde{u}}{\partial \tilde{x}^2} + \frac{\partial^2 \tilde{u}}{\partial \tilde{y}^2}\right) \quad (7)$$

$$\frac{\partial \tilde{v}}{\partial \tilde{t}} + \tilde{u}\frac{\partial \tilde{v}}{\partial \tilde{x}} + \tilde{v}\frac{\partial \tilde{v}}{\partial \tilde{y}} = -\frac{1}{\rho}\frac{\partial \tilde{P}}{\partial y} + \tilde{\mu}\left(\frac{\partial^2 \tilde{v}}{\partial \tilde{x}^2} + \frac{\partial^2 \tilde{v}}{\partial \tilde{y}^2}\right) \quad (8)$$

The vibrating beam equation is as follows [14]:

Kinetic energy equation:

$$T = \int_0^L \frac{1}{2}\left[\rho A\left(\frac{\partial y}{\partial t}\right)^2 + \rho I\left(\frac{\partial \psi}{\partial t}\right)^2\right]dx \quad (9)$$

Potential energy equation

$$V = \int_0^L \frac{1}{2}\left[EI\left(\frac{\partial \psi}{\partial x}\right)^2 + \frac{1}{2}kGA\left(\frac{\partial y}{\partial x} - \psi\right)^2\right]dx \quad (10)$$

And finally the piezoelectric equation is as follows [15]:

$$\Delta L = d_{31}.V.\frac{L}{t} \quad (11)$$

$$\Delta W = d_{31}.V.\frac{W}{t} \quad (12)$$

$$\Delta t = d_{33}.V \quad (13)$$

3. RESULTS AND DISCUSSIONS

At first the resonance frequency and Eigen value of the micro-beam is obtained. This information presented in Figure 2 and table 1.

	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
Eigen value	3.2e-4	9.2e-5	1.5e-5	-0.8e-6	1.5e-4	3.6e-5	8.2e-5	6.2e-5	-1.5e-4	-1.4e-5
Resonance frequency	5.79e5	3.91e6	1.21e7	1.74e7	2.29e7	3.62e7	5.62e7	5.99e7	7.15e7	9.17e7

TABLE 1: Frequency and Eigen value of the micro-beam.

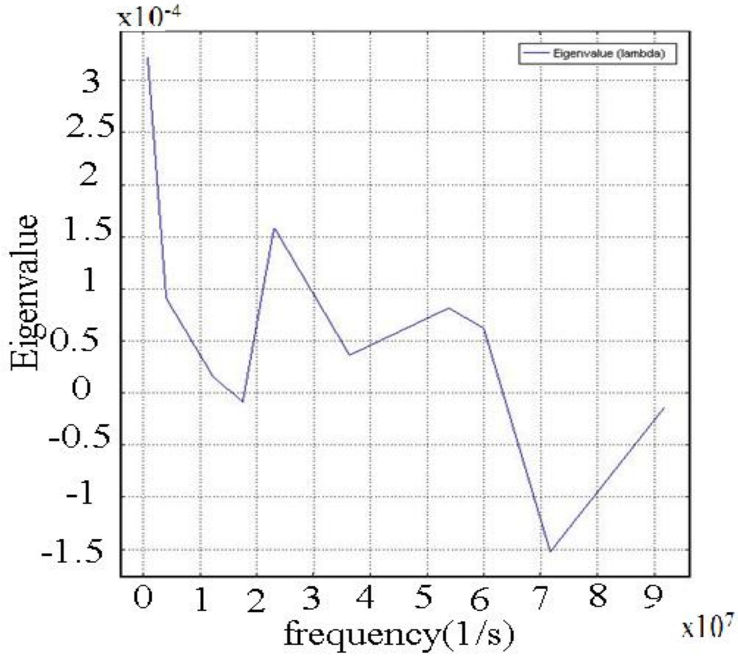

FIGURE 2: Frequency and Eigen Value of the micro-beam.

Now with changing input wind velocity, frequency response of system obtained. The average velocity is considered 1 m/s:

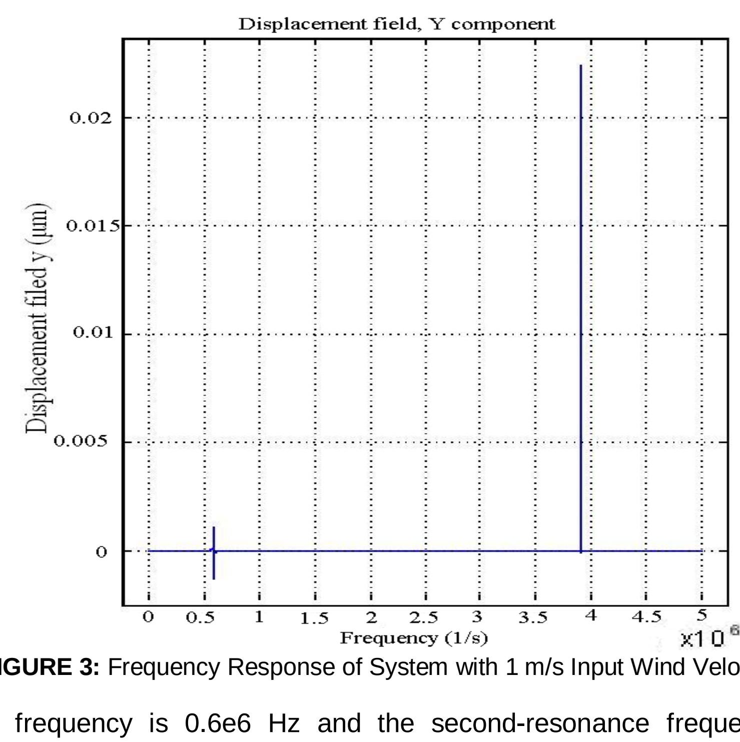

FIGURE 3: Frequency Response of System with 1 m/s Input Wind Velocity.

First resonance frequency is 0.6e6 Hz and the second-resonance frequency is 3.9e6 Hz. Therefore, the resonance frequency for system with 1 m/s average input wind velocity is different with Eigen value of system. And now the average wind velocity changes into 10 times of the first amount of wind velocity and then check the frequency response of system.

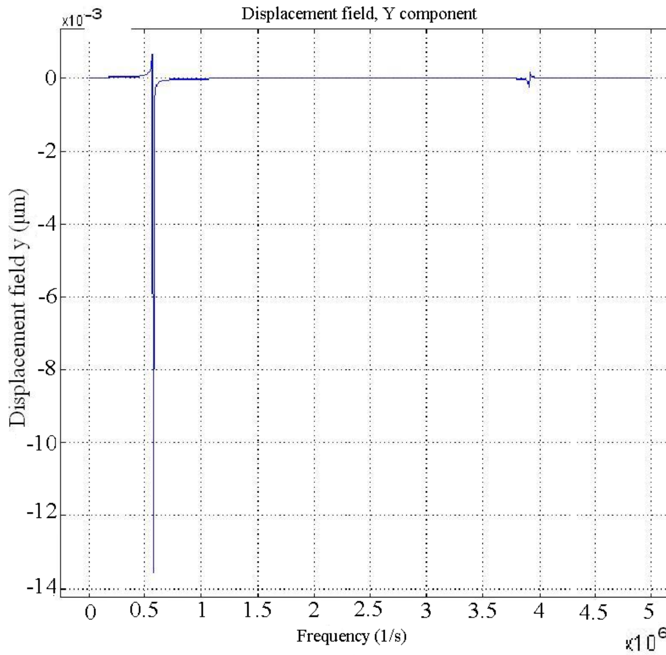

FIGURE 4: Frequency Response of System with 10 m/s Input Wind Velocity.

With this changing, the first resonance frequency is 0.6e6 Hz and the second-resonance frequency of is 3.9e6 Hz and the resonance frequency for system with 10 m/s average input wind velocity is different with Eigen value of system but these values are not different with the system while average of input wind velocity was 1 m/s. Now the average of input wind velocity changes into 100 m/s and the frequency response of system will be checked.

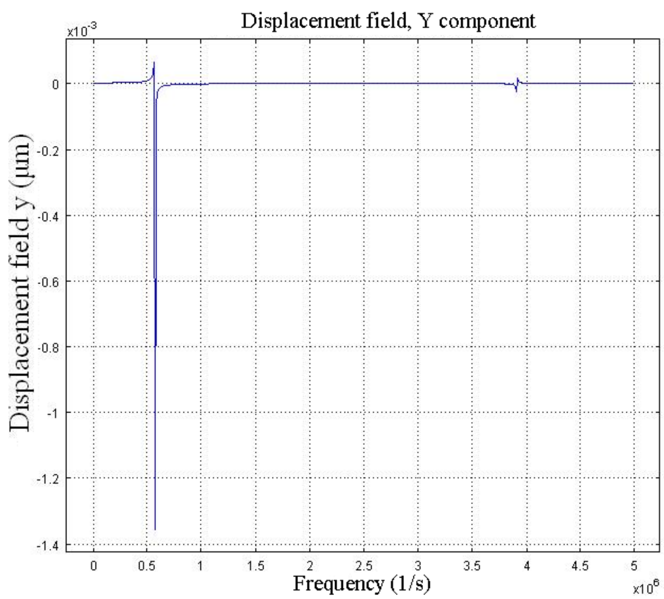

FIGURE 5: Frequency Response of System with 1 m/s Input Wind Velocity.

Consequently With this changing, the first resonance frequency still is 0.6e6 Hz and the second-resonance frequency is 3.9e6 Hz and the resonance frequency for system with 100 m/s average velocity input wind is different with Eigen value of system but these values are not different with the system while average of input wind velocity was 1 m/s and 10 m/s. Now applied magnetic field to the system is changed into the ten times the first amount of magnetic field definition.

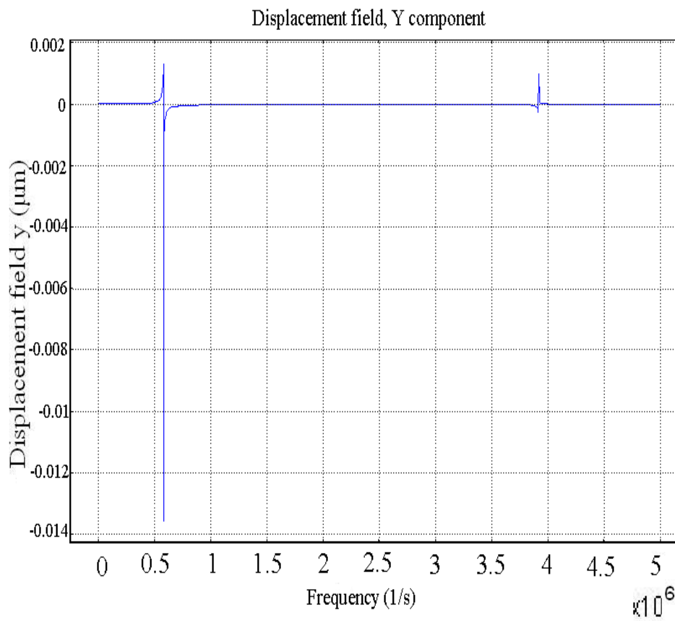

FIGURE 6: Frequency Response of System with Changing in Magnetic Field.

With changing the voltage to 10 V frequency response of system analyzed. Again, maximal frequency is like situations before with the same frequency.

4. CONCLUSIONS

As was shown, the natural frequencies and frequency response of the system with different inputs analyzed and therefore amount of natural frequency is different with frequency response of system with various inputs. Consequently there is the lack of a significant difference in maximum frequency response for micro-fluid structure interaction with changing inputs.

5. REFERENCES

[1] Dargush, G., and Banerjee, P., 1990. “Development of an integrated bemfor hot fluidstructure interaction”. Journal of Engineering for Gas Turbines and Power-Transactions of the ASME, 112-2 , pp. 243–250.

[2] Fan, D., and Tijsseling, A., 1992. “Fluid-structure interaction with cavitation in transient pipe flows”. Journal of Fluids Engineering-Transactions of the ASME, 114-2 , pp. 268–274.

[3] Fujita, K., 1990. “Flow-induced vibration and fluid structure interaction in nuclear power plant components”. Journal of Wind Engineering and Industrial Aerodynamics, 33-1-2 , pp. 405–418.

[4] Lui, A., and Lou, J., 1990. “Dynamic coupling of a liquid-tank system under transient excitations”. Journal of Ocean Engineering, 17-3 , pp. 263–277.

[5] Vonestorff, O., and Antes, H., 1991. “Onfem bem coupling for fluid structure interaction analyses in the time domain”. International Journal for Numerical Methods in Engineering, 31-6 , pp. 1151–1168.

[6] Olson, L., and Bathe, K., 1985. An infinite element for analysis of transient fluid-structure interaction”. Journal of Engineering with Computers, 2 , pp. 319–329.

[7] Pinsky, P., and Abboud, N., 1989. “Two mixed variational principles for exterior fluid structure interaction problems”. Journal of Computers and Structures, 33-3 , pp. 621–635.

[8] Kock, E., and Olson, L., 1991. “Fluid structure interaction analysis by the finite element method – a variational approach”. International Journal for Numerical Methods in Engineering, 31-3 , pp. 463–491.

[9] Zeng, X., J., B., and MacCamy, R., 1992. Stable variational coupling method for uid- structure interaction in semi-innite media”. Journal of Vibration and Acoustics, Transactions of the ASME, 114-3 , pp. 387–396.

[10] Seybert, A.F.and WU, T., and Li, W., 1993. “A coupled fem bem for fluid-structure interaction using ritz vectors and eigenvectors”. Journal of Vibration and Acoustics, Transactions of the ASME, 115-2 , pp. 152–158.

[11] Srikar Vengallatore ,MichaelP. Paı¨doussis ,2010, Dynamics of microscale pipes containing internal fluid flow: Damping, frequency shift, and stability, Journal of Sound and Vibration.

[12] Wang L., 2009, Vibration and instability analysis of tubular nano- and micro-beams conveying fluid using nonlocal elastic theory , Physica E.Comsol help V. 4.1 2010.

[14] Nikkhah Bahrami M.,Vibration Theory and application in engineering. 2012, university of Tehran publication

[15] Schwartz M. ,2002, ENCYCLOPEDIA OF SMART MATERIALS, John Wiley & Sons, Inc.

Multi-Response Optimization For Industrial Processes

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Abstract

Process optimization is a very important point in modern industry. There are many classical optimization methods, which can be applied when some mathematical conditions are verified. Real situations are not very simple so that classical methods may not succeed in optimizing; as in cases when the optimization has several contradictory objectives (Collette, 2002).

The purpose of this work is to propose an optimization method for industrial processes with multiple inputs and multiple outputs (MIMO), for which the optimization objectives are generally contradictory and for which some objectives are not maximum or minimum but performance criteria.

The first step of this method is modeling each process response by a quadratic model. After establishing the model, we use a simplified numerical optimization algorithm in order to determine values of the parameters allowing optimizing the different responses, for MIMO processes.

This method will also allow finding optimum target values for multiple inputs single output processes.

Keywords: Multi-Response, Optimization, Discrete, Numerical, Modeling.

1. INTRODUCTION

A multi-objective optimization problem for an industrial process implies simultaneously minimizing some criteria defined in the same space, such as minimizing costs while maximizing performance. These optimization criteria are contradictory and the solution is a balance between the two objectives, as shown in figure 1 (Pareto,1896).

Pareto line (boundary) contains all balanced solutions. In figure 1, A and B are two points of Pareto line: A does not dominate B, B does not dominate A, but both of them dominate C. The purpose of multi-objective optimization is to find the Pareto line for a given problem (Gräbener, 2008). The dominant solutions of an optimization problem are those represented by the points on the Pareto boundary. Therefore for n objective functions there are C_n^2 boundaries to compute and the solutions are to be found in the domain limited by these C_n^2 boundaries.

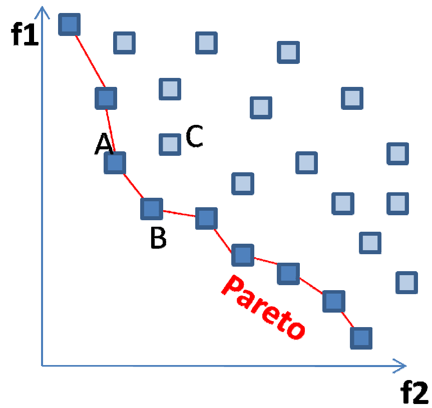

FIGURE 1: Pareto Line (boundary).

2. MULTI-OBJECTIVE OPTIMIZATION

Collette classified optimization methods in two categories, the scalar methods which transform the multi-objective problem in a mono-objective one and heuristic methods (Collette, 2002), which are generally stochastic iterative algorithms leading to a global optimum. A third method, using the desirability notion, was introduced by E.C Harrington (Harrington, 1965) and developed by G. Derringer (Derringer, 1980), in order to compensate for disadvantages of classic scalar methods.

2.1 Scalar Methods

These methods propose an a priori resolution by simplifying multi-objective problems in mono-objective ones. The scalar methods are weighting method (Coello, 2000), the ε-constraint method (compromise method)(Miettinen, 1999) and the goal method (Dean and Voss, 2000).

The weighting method computes a weighted sum of the objectives.

The problem becomes then:

$$\begin{cases} minF(X) = \sum_{i=1}^{m} W_i f_i(X) \\ \sum_{i=0}^{m} W_i = 1 \; and \; W_i \geq 0 \end{cases} \quad (1)$$

The weights Wi values are chosen by the designer. By giving a greater value to a weight W_i, the function fi will have a greater influence in the weighted sum. Generally it is interesting to solve some multi-objectives problems by considering some weights sets, but this type of solution become expensive in computing time.

In the case of a two objectives problem the equation (1) becomes:

$$f_2(X) = \frac{1}{w_2} F(X) - \frac{w_1}{w_2} f_1(X) \quad (2)$$

Since we want to obtain a minimum for F(X), we look for a line of directory coefficient $-\frac{w_1}{w_2}$ with the smallest ordinate and tangential to the set of Pareto optimal solutions.

The weighting method allows finding only the solutions existing on the convex Pareto boundary (Geoffrion, 1968). The ε-constraint method does not present this disadvantage. In this method, one of the functions is considered the optimization objective. The remaining functions are considered constraints and the problem becomes:

$$\begin{cases} \min_{X \in \mathbb{R}^n} f_{i0}(X) \\ f_i(X) \leq \varepsilon_i \; for \; i \neq 0 \end{cases} \quad (3)$$

As in the weighting method, it is possible to solve successively some mono-objective optimization problems with constraints, using each time different εi sets.

In the goal method, the problem becomes a mono-objective one as follows:

$$\begin{cases} \min_{X \in \mathbb{R}^n} \alpha \\ f_i(X) - \alpha . d_i \leq z_i \; for \; i = 1, \dots, m \end{cases} \quad (4)$$

In this equation, z is a point of $\mathbb{R}_m$ and d a vector of $\mathbb{R}_m$

where m is the number of optimization criteria. In this method, a priori values are to be chosen for the point z and for the direction d. For a same point z, it is then necessary to solve more mono-objective optimization problems with different directions d. The computation is repeated subsequently for more values of z, increasing thus the computation time.

2.2 Evolutionary Methods

These methods are used for complex optimization and search problems. The metaheuristics are generally stochastic iterative algorithms leading to a global optimum (Holland, 1992), such as the simulated annealing, genetic algorithms, the tabu search or the ant colony optimization.

The main advantage of such methods is their capability to avoid local optimums (maximum or minimum), by allowing a momentary degradation of the situation, in contrast to classical methods (Collette, 2002).

2.3 The Desirability Function

The idea of desirability is based on a weighting of the objective functions as in scalar methods but by using a product and by transforming all responses in a unique dimensionless desirability scale (individual desirability). The desirability functions (d_i) values are between 0 and 1.

The desirability function method allows rewriting an optimization problem as a mono-objective problem by proposing a unique composed criterion from some simple criteria; using classical methods then solves the mono-objective optimization problem.

The individual desirability functions are defined as follows:

$$\begin{cases} \left[\frac{Y_i - Y_{i\,min}}{\mu_i - Y_{i\,min}}\right]^p \text{ if } Y_{i\,min} \leq Y_i < \mu_i \\ \left[\frac{Y_i - Y_{i\,max}}{\mu_i - Y_{i\,mnax}}\right]^q \text{ if } \mu_i \leq Y_i < Y_{i\,max} \\ 0 \text{ if } Y_i < Y_{i\,min} \text{ or } Y_i > Y_{i\,max} \end{cases} \quad (5)$$

Where Yi min is the lower limit for Y_i value (d_i = 0), Yi max is the upper limit for Y_i value (d_i = 0), μ_i is the target optimal value for Y_i (d_i = 1) and p and q are importance factors for the desirability function.

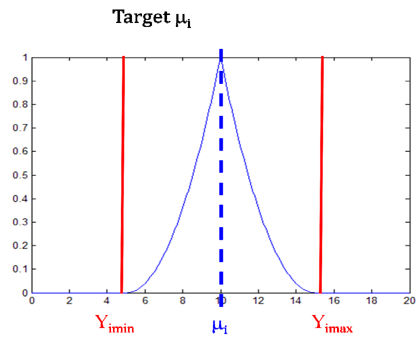

FIGURE 2: Desirability Function.

The set of individual desirability functions is used to compute a global desirability D (He and Zhu, 2008), by:

$$D_j = \left(\prod_{i=1}^{n} d_{i,j}\right)^{1/n} \qquad (6)$$

Since D is a geometric mean, it is equal to zero if one of the individual desirability functions is zero, rejecting thus a function in which one of the objectives is not at all attained, even if the other objectives are attained.

The maximal value for D is obtained when the combination of different responses is globally optimal.

3. LIMITATIONS OF USUAL METHODS

The scalar methods do not leave a choice to the user. They propose a unique solution, even if there are several possibilities. Moreover, sometimes-non-dominated solutions are impossible to obtain, whatever the coefficients (when the Pareto boundary is not convex). Finally, there are some non-additive quantities (Collette, 2002).

The metaheuristic approaches address some of these problems. However, constructing an efficient evolutionary algorithm is very difficult, since evolutionary processes are algorithm and parameter choice sensitive, and problem representation sensitive. Best such methods are based on sound knowledge and experience of the problem, on much creativity and on good comprehension of evolutionary mechanisms (Zhang, 2005).

Moreover, these methods may be less performing when applied to strongly constrained problems. Furthermore, they do not allow having some information on the Pareto boundary, and therefore it is impossible to evaluate the quality of the solutions (Terki, 2009).

In the case of the global desirability function, identical weights are generally used if all responses have the same importance. However, the optimum depends on the weights allocated to each response. The greatest difficulty is the choice of weights allocated to the individual desirability functions and of the model for the mono-objective optimization of the global desirability function.

For example, when considering a process with three criteria, corresponding to three different desirability functions, even if the individual desirability functions have values only of 10%, 20%, …, 90%, there are still 9!/(9-7)! = 504 different possible global desirability functions.

The choice of the mono-objective optimization model is complex due to the great number of possible choices and to the limitations of the different methods.

Other limitations come from the inner nature of the problem: optimization means maximizing or minimizing an objective, while in industrial processes, it is necessary to obtain precise values for performance criteria, within established acceptance limits.

In order to treat the optimization problem globally, it is necessary to solve a multi equations multi variables system. Since analytical resolution is very difficult, we propose a numerical approach, described in next section.

4. NUMERICAL APPROACH

An industrial process optimization by the means of this approach has some advantages:

- The possible interval is given by acceptable limits;
- The continuous variables may be considered as being discontinuous, since measure instruments give discontinuous values, according to their limits;
- The number of variables affecting the response cannot exceed some limit in industrial processes;
- The targets of the processes are generally defined within limits.
- These properties allow us to propose a method with the following steps:
- In order to have discrete variables, the digitalization step is defined according to the acceptable limits of measure instruments.
- All responses satisfying the constraints (validity domain) are computed.
- The intersection of different validity domains of each objective function gives the global validity domain, for all objective functions, but the user makes the final choice of the optimal solution.

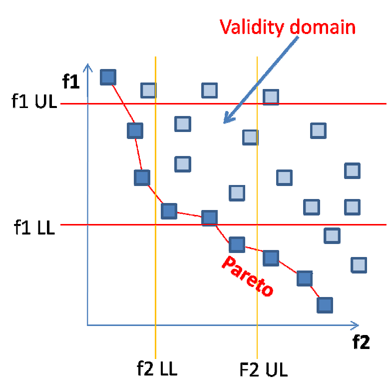

FIGURE 3: Validity Domain (LL: Lower Limit, UL: Upper Limit).

It is also possible to diminish the limits if the number of solutions is too big, or to increase them if there are not enough solutions.

This method has the advantage, when minimizing, to be closer to the optimum than the analytical methods, which generally use approximations.

Moreover, the use of complex mathematical formulations is not always well accepted in industry; it is thus interesting to have a simple optimization strategy, based on numerical calculation.

The proposed algorithm has also the advantage of proposing more possible solutions, depending on the conditions on the variables. Generally, when constraints are very restrictive, the number of proposed solutions diminishes. The solutions can be different, depending on the expressed need on input or response variables. The user can choose to have a solution as close as possible to the target, whatever the conditions on the input variables, or to favor the conditions on the input variables over the precision of the solution.

In order to diminish the number of proposed solutions, it is possible to set additional constraints, according to the objectives and initial constraints.

It is interesting to define the interval of acceptable values and the optimization algorithm to obtain several solutions, in order to have an appropriate choice.

For example, suppose the two solutions as follows:

a) $X_1 = 3$, $X_2 = 10$ and $X_3 = 100$, responses $Y_1 = 80\%$ and $Y_2 = 4$

b) $X_1 = 1$, $X_2 = 5$ and $X_3 = 60$, responses $Y_1 = 79\%$ and $Y_2 = 3.9$

If the objective is to have a unique optimum, the proposed solution will be a.

If the optimization objective is to propose different solutions, both solutions have approaching values for responses but different values of input variables. The choice depends on input variables values and constraints.

5. APPLICATION EXAMPLE

An optimization method is generally based on a mathematical model allowing expressing the objective function versus the influential parameters. The factorial and Taguchi experiments and the quadratic models allow modeling processes depending on several controllable factors and having objectives of product quality or costs (Montgomery, 2001), (Dean, 2000), (Fowlkes,1995). Our example process is modeled by quadratic functions.

The problem considered in the application example concerns a welding machine for chips bags and the objective is to optimize the welding process by finding the manufacturing conditions which give the best visual quality of the weld and weld strength close to 85 (Oueslati, 2001).

Depending on the behavior of the response versus input factors and depending on the optimization objectives, it is possible to obtain several vectors Xi satisfying these conditions or to find out that there is no such a vector.

The experiment is designed with three factors: the temperature (X_1), the pressure (X_2) and the tightening duration (X_3) and with two responses: the weld strength (Y_1) and the visual weld quality (Y_2).

The values for each input variable are given in the following table:

Level	Temperature (℃)	Pressure (Kg/dm^3)	Tightening duration (Seconds)
-1	120	50	0.2
1	180	150	2

The objective is to find out the values for X_1, X_2 and X_3 in the domain where Y_1 is close to 85 (with an acceptable limit of $\pm$ 5) and where Y_2 is bigger than 4.

Experiment:

	Temperature	Pressure	Duration	Resistance	Quality
1	-1	0	0	65.32	3.87
2	1	0	0	81.55	2.32
3	0	-1	0	91.45	3.14
4	0	1	0	93.29	4.36
5	0	0	-1	70.53	3.54
6	0	0	1	80.92	2.46
7	1	1	1	41.83	2.07
8	-1	1	1	89.97	3.01
9	1	-1	1	44.53	1.11
10	-1	-1	1	89.85	2.04
11	1	1	-1	91.53	2.77
12	-1	1	-1	11.25	4.48
13	1	-1	-1	92.94	2.04
14	-1	-1	-1	13.2	3.35
15	0	0	0	86.89	3.81
16	0	0	0	91.03	3.63
17	0	0	0	93.11	3.46
18	0	0	0	89.41	3.74
19	0	0	0	88.71	3.62

Response modeling:
Each response is defined by a quadratic model:

$Y_i = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + a_{12}X_1X_2 + a_{13}X_1X_3 + a_{23}X_2X_3 + a_{11}X_{12} + a_{22}X_{22} + a_{33}X_{32}$

	a_0	a_1	a_2	a_3	a_{12}	a_{13}	a_{23}	a_{11}	a_{22}	a_{33}
Y_2	3.66	-0.64	0.50	-0.55	0.00	0.14	0.01	-0.49	0.00	-0.58
Y_1	90.47	8.28	0.00	6.77	0.00	-31.68	0.00	-16.72	0.00	0.00

Classical optimization:
By using a scalar method, the solution is:

X_1 = 143.94, X_2 = 115 1.38 and X_3 = 0.98; responses Y_1 = 85 and Y_2 = 4.0

One can see that the proposed solution is not optimal and that there is no other choice; for example, we could lower the constraints on input variables.

If the objective were to find a maximum for both functions, the classical optimization solution would be:

X_1 = 137.40, X_2 = 161 and X_3 = 0.43; responses Y_1 = 86.32 and Y_2 = 2.6

This solution is not optimal; the input variables values are not within the limits, there is no correspondence between response values and input values according to the model and, finally, the Pareto boundary is not computed.

Optimization using desirability function:
As is generally done, we used equal weights for individual desirability functions. The optimum of the global desirability function is graphically found. The solution obtained is:

$X_1 = 143.1$, $X_2 = 150$ and $X_3 = 0.95$; responses $Y_1 = 84$ and $Y_2 = 4.36$

The graphic research for the optimum is possible even for the three variable function, because after the statistical analysis of effects, one of the parameters is found as being non influent. However, this method cannot be used for more complex functions.

Numerical optimization:
Each response is submitted to some constraints. In order to diminish the number of possible solutions, there were diminished the acceptable limits on the responses:

	Objective	Lower Limit	Upper Limit
Y_1	85	84	86
Y_2	>4	4	

We begin by some fifteen iterative computations on the three variables. When the validity domain is found, it is possible to have another iterative computation on this domain, in order to be closer to the constraints on the input and output variables.

After the first iterative computation, four possible solutions were found:

	X_1	X_2	X_3	Y_1	X_4
Solution 1	138	150	1.15	85.5	4.3
Solution 2	142.5	150	1.01	85.9	4.3
Solution 3	147	150	0.61	84	4.3
Solution 4	147	150	0.74	85.5	4.3

In order to make a choice, the costs generated by the conditions may be used as additional criteria.

For instance, the difference between the tightening duration obtained from solutions 1 and 3 is of 0.54s, i.e. a time about 50% shorter than if one chooses the third solution, but one must mention that this last solution is 6% costlier in energy consumption.

One can also see that different solutions are obtained when changing the digitalization step.

In order to have a smaller number of possible solutions, the limits on the responses can still be diminished, for example to 0.5 for Y_1 and a minimum of 4.38 for Y_2. In this case, the proposed solution is: $X_1 = 143.4$, $X_2 = 150$, $X_3 = 0.88$; $Y_1 = 84.5$ and $Y_2 = 4.38$.

6. CONCLUDING REMARKS AND FUTURE WORK

The proposed method allows optimizing in several steps a multiple input/multiple output process, i.e.:

- modeling each response by a quadratic function or a Taguchi model;
- finding the variables values satisfying the objectives by an iterative numerical calculation of the responses;
- obtaining the global validity domain by the intersection of all domains previously found;

- making choices of acceptable solutions in this global domain (depending on costs or on another criterion) and finally;
- proposing an optimal solution, by imposing if necessary an additional constraint on the objectives.

The first interest of this optimization method is the possibility to make an optimization on more variables and more responses and getting closer to optimum values, instead of using an analytical model. Moreover, this method allows finding several different solutions. Finally, it is based on numerical calculation, being thus simpler than the analytical methods.

The numerical search of optimal solution assumes that the quadratic model of the responses is valid.

Future work will concern the verification of the model's validity and some more applications of the method on industrial cases.

Another interest will be the comparison of performance between quadratic or Taguchi models and algorithms such as artificial neural networks or genetic algorithms.

7. REFERENCES

[1] Bénabès, J., Bennis, F, Poirson E., & Ravaut, Y. (2010), Interactive optimization strategies for layout problems, International Journal on Interactive Design and Manufacturing, 4(3):181–190, 2010.

[2] Collette, Y. & Siarry, P. (2002), Optimisation multiobjectif, Eyrolles, 2002.

[3] Terki, A. (2009), Analyse des performances des algorithmes génétiques utilisant différentes techniques d'évolution de la population, PhD thesis, University Mentouri, Constantine, 2009

[4] Fowlkes, W.Y. & Creveling, C.M. (1995), Engineering Methods for robust Product Design, Addison-Wesley, 1995.

[5] Coello, C. A., An updated survey of ga-based multiobjective optimization techniques. ACM Comput. Surv., 32(2):109–143, 2000.

[6] Dean A., & Voss D. (2000), Design and Analysis of Experiments, Springer, 2000.

[7] Derringer, G. and R. Suich. Simultaneous optimization of several response variables, Journal

[8] of Quality Technology, vol. 12, 214 - 219, 1980.

[9] T. Gräbener & A. Berro, Optimisation multiobjectif discrète par propagation de contraintes, Actes JFPC, (INRIA-00293720), 2008.

[10] E. Harrington, The desirability function, Industrial Quality Control, 21, 494 - 498, 1965.

[11] Holland, J. H., Adaptation in Natural and Artificial Systems : An Introductory Analysis with Applications to Biology, Control and Artificial Intelligence. MIT Press, Cambridge, MA, USA, 1992.

[12] Miettinen, K., Nonlinear Multiobjective Optimization, volume 12 de International Series in Operations Research and Management Science. Kluwer Academic Publishers, Dordrecht, 1999.

[13] Montgomery, D.C. (2001), Design and Analysis of experiments, 5th ed., John Wiley and Sons, 2001.

[14] Zhang, J., Chung, H. S. H., and Zhong, J., Adaptive crossover and mutation in genetic algorithms based on clustering technique, pages 1577–1578, 2005.

[15] Z. He,P. F. Zhu., A Note on Multi-response Robust Parameter Optimization Based on RSM. Management of Innovation and Technology, IEEE International Conference. 1120 - 1123, 2008.

[16] Oueslati, H. (2001), Optimisation simultanée de plusieurs réponses dans le cas de fabrication, Ecole Polytechnique de Montréal, 2001.

[17] Pareto, V., Cours d'´economie politique : professeur à l'Université de Lausanne. Numéro vol. 1. F. Rouge, 1896.

[18] http://www.cours.polymtl.ca/mth6301/mth6301-presentations/2001/Oueslati2001.pdf.

Time and Space

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Abstract

In this paper I will try to develop a theory that will relate time and space. I will try to develop a model that might be used to understand the idea of time and space.

Keyword: Projection, Correlate, Orthogonal.

1. INTRODUCTION

I want the reader here to think of a pizza of 12 slices. Before taking any slice of the pizza (the pizza is complete) as we take the projection of the pizza in all directions we will get the same function. For simplicity let us make the model digital. Let us take 12 projections. Starting from 0 degrees were we have the edge of the first slice rotating 15 degree around the pizza and taking the first projection. Then rotating around the pizza 30 degree and taking the second projection .We do that to get the 12 projections. Here we will get the same 12 functions. Here we can say that the functions are dependent (time) the opposite of independent (space).

2. THE MODEL .

As we take the first slice of the pizza from 0 degree to 30 degree. and we take the 12 projections starting at 15 degree for the first projection and rotating 30 degrees around the pizza for each another projection. We will get 12 functions that are more independent. Here we can say we are going from time to space.

As we take the second slice of the pizza (from 0 degree to 60 degree of). And we take the 12 projections starting at 15 degrees and rotating 30 degree for each projection. The more independent the functions will be

As we can see as long as we are in the first quarter the more slices we take the more independent the projection functions will become. By that I mean the more orthogonal they will be. We can say here that we are going from dependent to independent (more orthogonal) functions or from time to space.

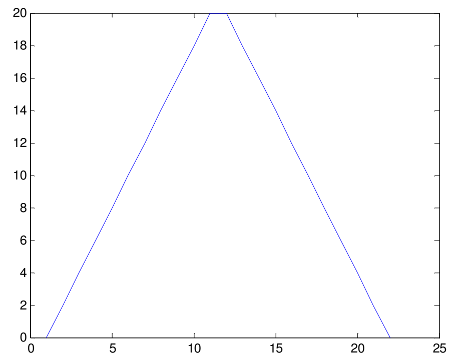

FIGURE 1

At this point a computer is needed to correlate data. Also a measurement of orthogonality is needed. We have for each case 12 deferent functions. From some work I did I found that the dimensionality for each case of the 12 functions is three. Which is consistent with the three dimension space in nature. By that I mean 3 functions out of the 12 functions can be used as bases to generate all 12 functions.

Using the same method. As we start taking slices from the second quarter of the pizza the 12 projection functions will become more and more dependent (going from space to time). In fact the maximum dependency we will get at 50% of the pizza. At this point we can say we are back to time.

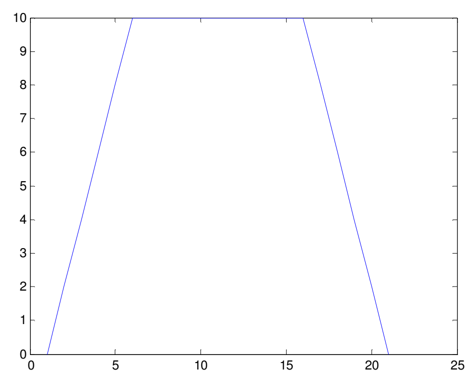

FIGURE 2

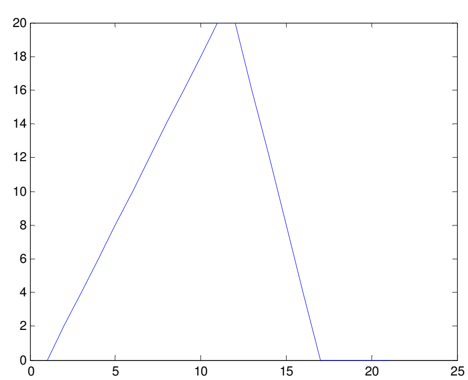

FIGURE 3

Using the same method. As we start taking slices from the third quarter of the pizza the 12 projection functions will start converting from dependent (time) to independent (space). In fact the maximum orthogonality of the 12 projection functions will happen at 25% of the pizza. At this point we can say we are back to space. This is similar to the fact that a baby stays 9 month inside his mother (3 quarters of the year).

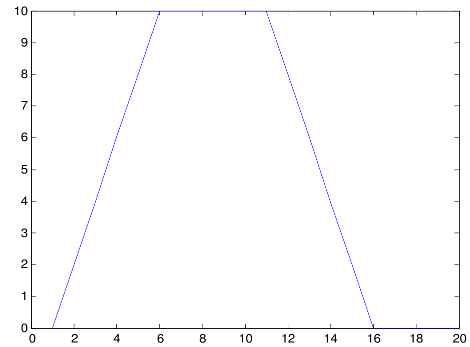

FIGURE 4

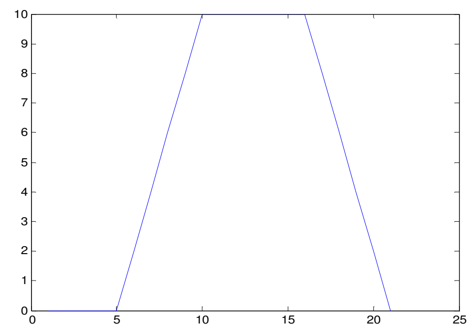

FIGURE 5

In the history of science and technology class in 1990 I had a feeling that the two equations E=1/2 m*v2 (were E is the Kinetic energy and m is the mass and v is the velocity) and E=m*c2 (were c is the speed of light) are related. My justification was that c is the speed limit but I was not able to justify the ½ factor. Dose this work justify that? are we in the 50% of the pizza domain for E=1/2 m*v2 and we are in the 100% of the pizza domain for E=m*c2 ?

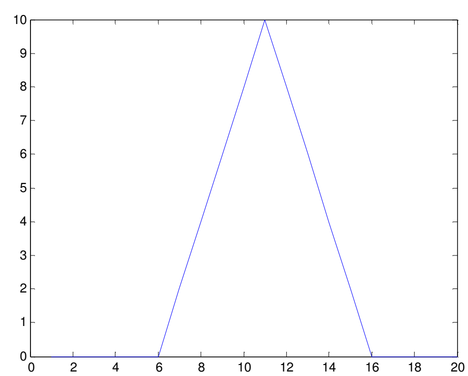

FIGURE 6

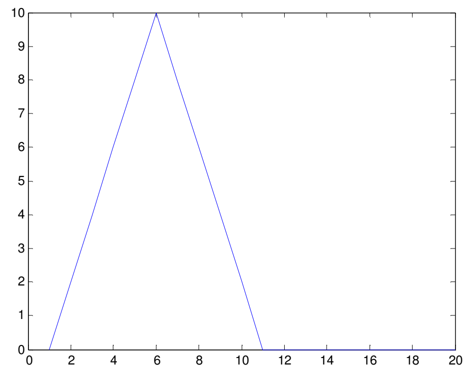

FIGURE 7

I am discussing a possible analogy for certain relativistic results. Any analogy that helps us to better understand the physics is fine. However, you must realize that analogies have their limitations. For example, water is sometimes used as an analogy for the flow of electric current in a circuit. This analogy has been very helpful for many students in their understanding of electric circuits. In using an analogy however, one must understand its limitations. Remember, science really only constructs models of observed phenomena. The excellence of the model depends on how well it predicts observed experimental results. If predictions from the model do not correspond with experimental results, the model is modified until there is agreement. I discuss this in Chapter 1 of the book “Airborne Doppler Radar: ... “ which was published by the AIAA (American Institute of Aeronautics and Astronautics). In that chapter, the basic philosophical view of science is discussed.

3. SPACE

In the history of science and technology class in 1990 I was able to proof that the universe is bounded. This is the proof. If we have a plate as the plate rotate at angler speed w. The tip of the plate will have a speed r.w (were r is the radius of the plate). As the radius gets larger the tip speed gets larger. But we know that the speed limit is c. As a result we can conclude that the universe is bounded. In fact, it is bounded by the relativity curve.

This is like Columbus and the age any body could have done it but no body did.

The question now is how can we integrate the bounded universe theory with the pizza model to come up with a clock that best describe the time and space system of the universe. An orange might help? But how?

About my thoughts about the finiteness of space, the analogy often used is that of the surface of the earth. The earth’s surface is finite, yet one can travel an infinite distance on it without ever crossing a previously traveled path. It is, of course, the curvature of the earth’s surface that is the basis of this. Einstein showed that a good model is to represent space as being curved from which one arrives at the “finiteness” of space.

4. SPECTRUM AND CLOCKS

A question that use to come to my mind while I am studying the spectrum of a signal is how much of time do we have to take ? Were do we start and were do we end?

To analyze this question let us think of simple and fundamental signal such as an exponential with time constant (t1). I think it is clear that if we take (5*t1) time we will have most of the information we need to find the spectrum.. Also I think of the inverse relationship between the time domain and the frequency domain ? It is clear for such a signal the cut of frequency is (1/t1).

This mean that the time constant is a parameter for the signal in the time domain and for the spectrum in the frequency domain .

At a specific instant we can not find the spectrum because to find the spectrum we have to integrate time out. But I am trying to find how much time do we need ? I think this is an estimation problem.

Another interesting fact is when we take a slower time frame or a faster time frame? And the relativity between two time frames? We might feel the inverse relationship between doubling the time constant lowering the bandwidth by the half factor?

Also interesting is clocks relative to each other? Say we have clock 1 and clock 2 and there is an integer number of clock 1 in clock 2 or the other way around.

At this point we can say the two clocks are in resonance? Or let me say that one clock is in the *orbit* of the other. I think in this example the inverse law relationship is clear and the relation between the time domain and the frequency domain can be seen?

Please think of the phasor diagram of sin massage AM signal were the origin is the sun and the earth is rotating around the sun as the tip of the carrier phasor and the moon rotate around the earth as the tip of the massage phasor from the tip of the carrier phasor. This motion can be filtered by a band pass filter With lower and upper cut off frequencies as the lower and upper side bands. Can we say that this filter resonate with this system?

This bring to my mind the sin massage FM and the spectrum of it. Please note that we have a carrier and side bands that are separated By the frequency of the massage?

I am very pleased and happy that I am still thinking deeply about science and engineering even though I have not been directly involved in it for quite a while. I do hope I continue to study and think about it .

Now, about "The Time Constant". First, the problem to which I refer in my paragraph has been a major one that has been studied for many years. It is one of the important topics discussed in the mathematical area of Harmonic Analysis.

In the paragraph, you should note that the concept of a 'time constant' has meaning only for a time function consisting of only exponential. For general waveforms, the problem I discuss is not a simple one. In the other paragraphs, I am referring to a phasor representation. In AM, the phasor representation of the modulation consists of two phasors rotating about the carrier phasor as I describe. In FM, an infinite number of such phasors are required (This representation gives a nice physical view of why there are an infinite number of harmonics in FM but not in AM].

I mention a possible relation to resonance. Resonance is a much different concept so that any modeling of a similarity between them would only be for mental convenience but would not have any basis for scientific considerations.

5. RESULTS

All simulation graphs given use a square instead of the pizza to simplify things. As we can see from our simulation results when the square is complete as we take four projections starting from 45 degrees and 90 degrees apart we will get four same and dependent functions Fig 1.

When one quarter of the square is off, as we take four projections starting from 45 degrees and 90 degrees apart, we will get three functions fig2, fig3. We will use the correlation factor as a measure of dependency. We find that the correlation factor of fig2 and fig3 is 2/3 and the correlation factor between fig3 and the third function is 0.90.

As we take one half of the square as we take four projections starting from 45 degrees and 90 degrees apart we will get two functions fig4 and fig5. These two figures are correlated by 66%.

When one fourth of the square is left, as we take four projections starting from 45 degrees and 90 degrees apart we will get three functions two of them are fig6 and fig 7 which are correlated by 33%.

If we take this data to the frequency domain we will find that there is a fundamental that depend on the size of the square. If the square is small the frequency is fast and if the square is large the frequency is slaw.

When one forth of the square is off, we have three signals which have two frequencies fig9 and fig10. Also when half of the square is off we have two signals with one dominating frequency fig11. When one forth of the square is left we have three signals of the same frequency fig 12.

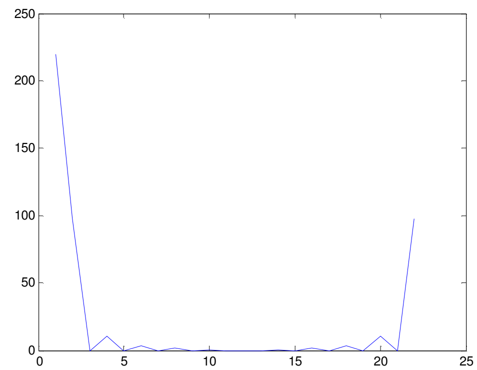

FIGURE 8

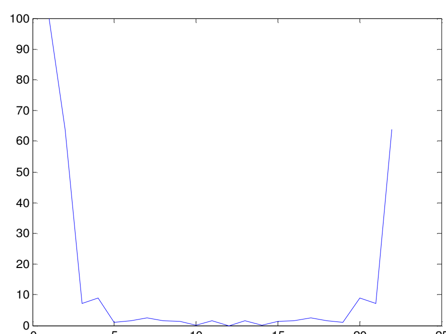

FIGURE 9

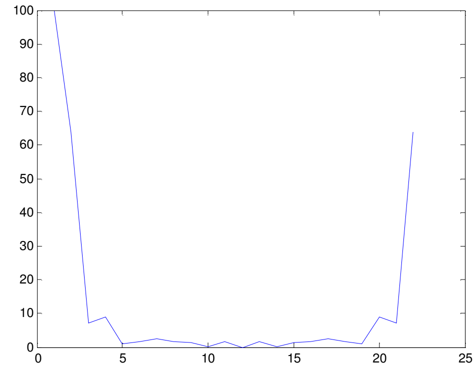

FIGURE 10

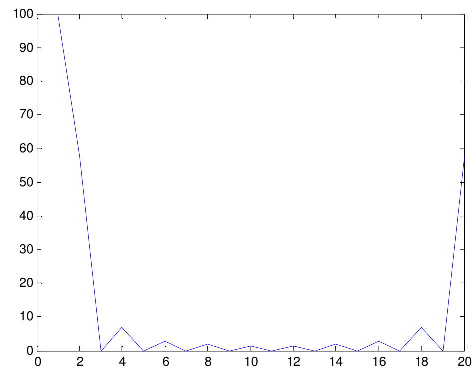

FIGURE 11

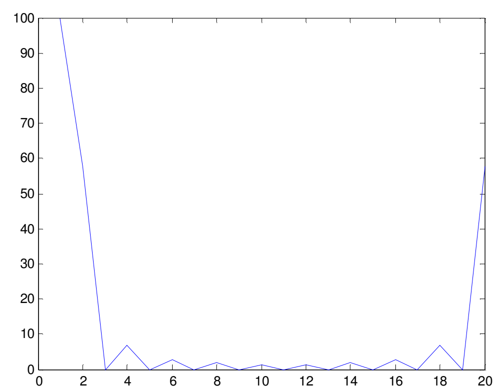

FIGURE 12

6. FUTURE RESEARCH DIRECTIONS

I think the future is to build a clock based on this theory. Let us think of a matrix 16x16. In the low right corner it has a matrix 2x2 and this matrix rotate as a function of time one cycle/sec. The next matrix is 4x4 in the low right corner rotate around it center one cycle/min and this rotation include the first 2x2 matrix. The third matrix is 8x8 matrix in the low right and rotate around it center one cycle/h. The fourth matrix is 16x16 and rotate around its center one cycle/day and so on.

If we project the matrix up and to the right we will have two waves that change as a function of time we can call them male and female because they complete each other to describe the matrix.

The amplitude spectrum of the projection do not change as a function of time so we can call it space.

Trying to built this kind of clock I think is potential for future research.

7. COMPARATIVE EVALUATION

This idea is by Prof. Arvin Grabel (the author of the microelectronics book) in the history of science and technology class. When I was doing my masters in the winter of 1991 I was the teaching assistant for Prof Martin Schetzen. At that time Stephen Hawking came to Northeastern University to give a lecture about time and space. Scientist at that time were trying to find one physics law that can explain atomic level phenomena and also explain the universe. One physics model for the small and the big. Dose this work do that? May be may be not?

The matrix model came to my mind from a lecture by Prof Ali Abur the electrical engineering chairman at northeastern university in power systems and network matrix class.

8. REFERENCES

[1] A. Papoulis , Probability , Random Variables, and Stochastic Process,2002.

[2] J. G. Proakis , Digital Communications, 2001.

[3] R. J. Schilling , Engineering Analysis ,1988.

[4] H. L. Van Trees , Detection, Estimation, and Modulation Theory,1968.

[5] J. G, Proakis , Inroduction to Digital Signal Processing ,1988.

[6] C. Chen , Linear System Theory and Design , 1984.

[7] S. Haykin , Communication System ,1983.

[8] T. H. Glisson , Introduction to System Analysis, 1985.

[9] Martin Schetzen, Airborne Doppler Radar, 2006.

[10] Martin Schetzen, The Volterra & Wiener Theories of Nonlinear Systems,2006.

[11] Martin Schetzen, Discrete System using Matlab, 2004.

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