Revisiting the Nonlinear Dynamics Behavior,Control Designs and Insights on Fluid Interactions of a Flexible Slewing Spatial Structures and their Applications to Engineering Science

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Abstract.

In this lecture,we presented a state -of -the art of the nonlinear dynamics and vibration controls of a flexible slewing structure systems, excited by an ideal and non-ideal energy source(Non-ideal).

Keywords: Flexible Structure, Slewing Motion, Fluid-Interactions..

1. The analyzed problem

The problem of rotating a cantilever beam from one direction to another is of long-standing interest. It has applications in the field of robotics among other places. For applications in space, the problem can be more complicated because of the highly flexible nature of the beam, and theories that include nonlinear inertia and bending terms may be required.In this paper, we revisit this kind of problem (slewing motions)[12,13, 14, 15]. We know that slewing control of a flexible structure is important in the control design of future industrial manipulators and a variety of space structures, mainly in the improvement of the manipulator performance

We remarked that the study of the dynamic behavior of slewing flexible structures has in view the study of lightweight and faster structures.The dynamics and control of slewing structures is complicated and is of continuing interest to researchers and scientists**.**

The applications of slewing structures may be divided into two groups : robotics and space structures.Typically,the modal analysis approach is the most popular model approach to space slewing structures and Finite Element approach to robotic apllications. Low inherent damping, small natural frequencies, and extreme light weights are among common characteristics of these systems wich make them vulnerable to any external / internal disturbances such as slewing manoeuvres, impacts, etc. Robot arms with the caracteristics quoted above are easy to carry out, need smaller actuators (motors) and can reach objectives in a greater workspace since they are thinner and longer than the rigid ones usually used for the same task.

Many of the published papers of slewing structures are concerning with the linear and nonlinear dynamics or (and) control of the flexible structure itself.

In dealing with flexible rotating structures the mutual interaction between the angular displacement of the slewing axis and the flexible structure deflection can be very important in high angular speed maneuvers. The dynamical systems where this interaction occurs are called non-ideal systems.In the ideal systems approach(traditional ones), there is no mutual interaction and only the slewing axis dynamics excites the slewing beam.We also mention that have few works in the current literature concerning the mutual interaction between a driving source and a rotor motion.

[1]was the first one to systematize the study of this kind of systems in which an unbalance is comparative large and the driving torque was small using asymptotic methods taking into account the energy of the driving source.Recently[2]presented a complete review of current literature on this kind of problems from 1902 to 2003 and [4] the authors revisited the non-ideal systems, using theory of invariant manifolds.

We remrked that little effort has been focused on DC motor –structure interaction which affects the dynamic properties of the slewing system,obviuosly.DC motors used in these applications are popular actuators not only because they can generate a wide range of torques and angular velocities, but also because they are quiet, clean and efficient.In the study with these kind of rotating structures, the interaction between the angular displacement also called slewing angle, and the flexible structure deflection variable can be very important in some cases, as in high angular speed maneuvers [5,6,7,8,9, 10].

.The goal of this work is dealing with this kind of interaction.Figures 1, illustrates an usual mathematical modeling and Fig 2, illustrates illustrates the forces and moments actuating in the slewinh motion modeling.

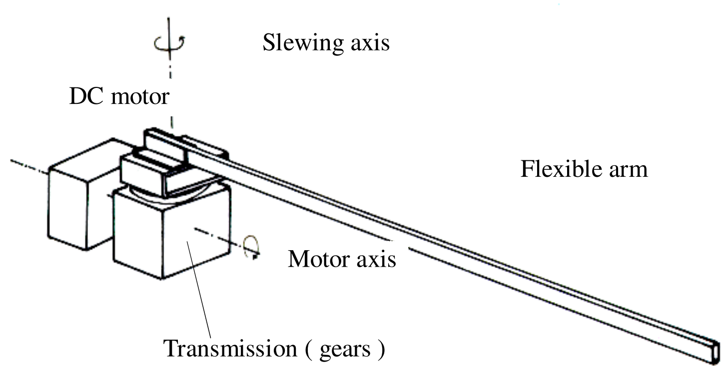

Figure 1a - Flexible manipulator (robotic application)[6]

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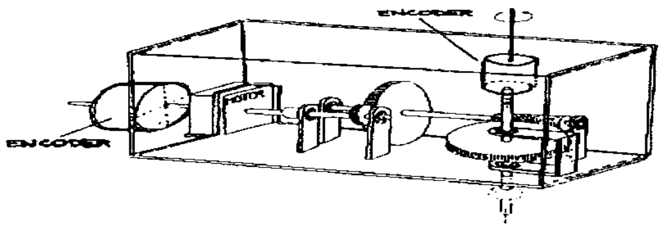

Figure 1b Transmission Gear system[6]

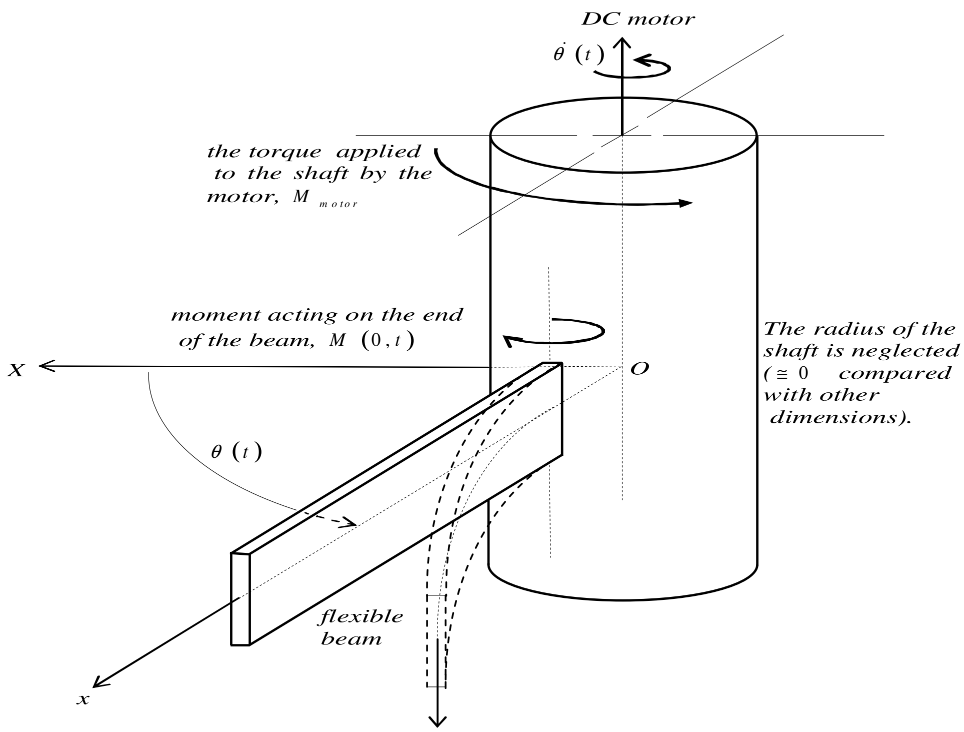

Figure 2. forces and moments atuacting in the slewing system[10]

The inclusion of the drag effect, in this case, incorporates, although in a simple manner, The interaction between the structure and the surrounding fluid as, for example, the air or the Water.

This interaction plays an important role as the fluid dissipates kinetic energy of the motion.

The Fig 3, illustrates the slewing flexible beam system interacting with a fluid[8, 9]

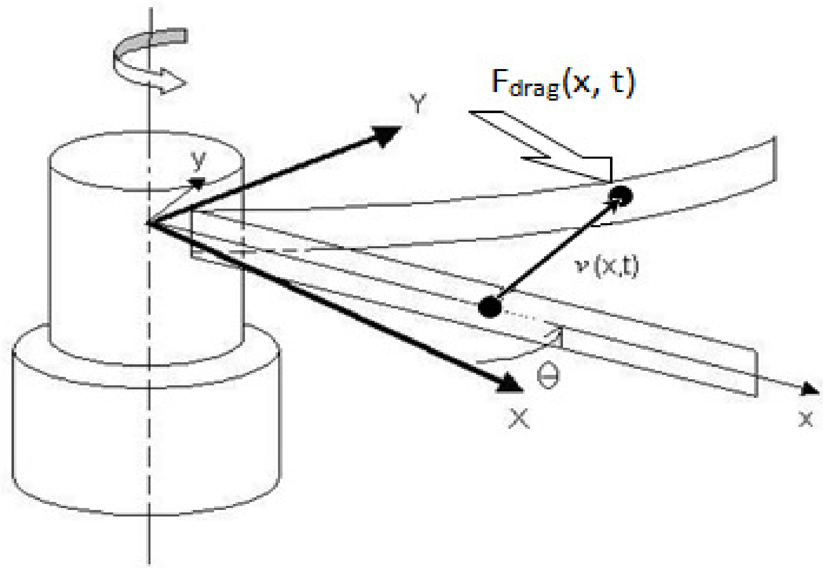

Figura 2: Slewing flexible beam system interacting with a fluid[8,9].

The system under investigation is presented and its geometric models (as proposed here) is presented and possible to apply them to several problems, such as lightweight robotic manipulators, solar panels and antennas in satellites, helicopter blades and so on.

In this lecture work, we deal with state- of the- art of the dynamics and vibration controls of flexible slewing structure systems, excited by a ideal and non-ideal energy source(Non-ideal).

We also include some experimental results (the experimental apparatus is shown in (Fg 3) .

Recently, we dealt with the position and vibration control of a single flexible slewing structure driven by a DC motor at the slewing axis. The position controlled over the current applied to de DC motor armature. To control the vibration of the flexible structure a shape memory alloy (SMA) is applied to them[11].

Figura 3. Apparatus experimental (Virginia Tech, Blacksburg, USA)[6]

2. Conclusions

In this lecture,we presented a state -of -the art of the nonlinear dynamics and vibration controls of a flexible slewing structure systems, excited by an ideal and non-ideal energy source(Non-ideal), including an interacting with a fluid and experimental apparatus.

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