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Editorial

Special Issue: Advances in Mechanics and Control

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The topic of mechanics and control is very important nowadays, with many applications in several fields, such as space research and the modeling of viruses. For this reason, the journal "*Symmetry*" has organized and published a Special Issue dedicated to this topic with the title "Advances in Mechanics and Control". The volume contains 16 published papers, which are briefly described herein.

The paper "Assessing Parameters of the Coplanar Components of Perturbing Accelerations Using the Minimal Number of Optical Observations", by Andrey Baranov, Vladimir Agapov, Natalya Golosova and Maksim Karatunov [1], developed a method to estimate the moment to apply and the magnitude of a variation in velocity for a maneuver-like perturbation of the motion of the center of mass of a spacecraft in a near-circular orbit. Information about the trajectory of the spacecraft before the maneuver and the optical observations of the angular position of the spacecraft after the maneuver are used in the process. This research considers the situations where there are only transversal (in-track) or transversal and radial components of the variation in velocity. This method also estimates the parameters of a continuous maneuver based on low-thrust propulsion. The method proposed in this paper allows the determination of the orbit of the spacecraft after the maneuver to be achieved much faster and more accurately compared to traditional methods.

The paper "Lifetimes of an Exomoon Orbiting a Jupiter-Like Planet in a Double Star System with the Mass of the Sun", by Allan Kardec de Almeida Junior, Vivian M. Gomes and Antonio Fernando Bertachini de Almeida Prado, [2] approaches the problem of the search for life outside Earth. It investigates the moons of exo-planets, looking for stable orbits that possess good conditions for life. The paper analyzes a system composed by a moon orbiting a planet that is orbiting a double star system. The initial conditions are assumed to have a symmetric configuration of two circular orbits. The condition of stability of the system is defined by the survival of the orbit of the moon for longer integration times. Regions of stable, unstable and collision orbits are mapped, and empirical linear equations are obtained for the border lines of these orbits.

The paper "Searching for Orbits for a Mission to the Asteroid 2001SN263 Considering Errors in the Physical Parameters", by Allan Kardec de Almeida Junior, Bruna Yukiko Pinheiro Masago Mescolotti, Ana Paula Marins Chiaradia, Vivian M. Gomes and Antonio Fernando Bertachini de Almeida Prado [3], searches for orbits that can be used in missions to the triple asteroid 2001SN263. The orbits are assumed to be perturbed by the oblateness of the main body, the solar radiation pressure and the gravitational fields of the two moons of the main body. It is also assumed that the values of the masses of these two moons contain errors. The main goal is to find orbits that can observe the three bodies of this system, even if the physical parameters of the bodies are not the expected ones. This is achieved by studying the effects of errors in all of the physical properties of the three asteroids in the trajectories described by a spacecraft. Important trajectories that can observe the desired bodies are found, even if the physical parameters are not corrected.

The paper "Low Thrust Propelled Close Approach Maneuvers", by Alessandra F. S. Ferreira, Antonio Elipe, Rodolpho V. De Moraes, Antônio F. B. A. Prado, Othon C. Winter

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and Vivian M. Gomes [4], studied the problem of orbital maneuvers that combine "gravity assisted" features with low-thrust features. The paper measures the efficiency of applying a continuous thrust when the spacecraft is passing close to a celestial body. The effect of this maneuver is studied using maps that give the energy variation in the spacecraft as a function of the parameters related to the maneuver. The thrust is applied in different parts of the trajectory to measure the effects of the locations of the thrusting arcs on the variations in energy. The effects of the variations in the direction of the thrust are also considered. Situations where this type of maneuver can be used to give extra energy to the spacecraft, while keeping control of the trajectory during the close approach, are identified.

The paper "Deflecting an Asteroid on a Collision Course with Earth Using a Powered Swing-By Maneuver", by Bruno S. Chagas, Antonio Fernando Bertachini de Almeida Prado and Othon Cabo Winter [5], uses the idea of a powered swing-by common in astrodynamics to make a deflection of an asteroid that may collide with Earth. The idea is to make an impact between a spacecraft and the asteroid in a passage close to Earth before the passage that may result in a collision with Earth, such that it increases the effects of the close approach and deflects the asteroid, avoiding the next passage that would result in a collision with Earth. This technique is important for scenarios where there is only a short time to deflect the asteroid. Three scenarios are considered: (i) when the impulse is applied before the close encounter, (ii) when it is applied during the close encounter and (iii) when it is applied after the close encounter. The paper shows that this technique can change the trajectory of the asteroid and avoid a collision with Earth, even if the warning time is short, not using a large variation in velocity.

The paper "Mapping Natural Orbits around Io", by Thamis C. F. Carvalho Ferreira, Antonio F. Bertachini A. Prado, Silvia M. Giuliatti Winter and Lucas S. Ferreira [6] shows several options for orbits around Io, which is the most volcanically active celestial body in the solar system. This natural satellite is a good candidate for being visited by future missions, because it is very important in terms of scientific research. The paper maps the initial conditions for orbits around Io, considering the effects from Jupiter and the J2 term from the gravity field of Io. The results showed the existence of some regions where the orbits last for more than 6 months.

The paper "Deployment and Retrieval Missions from Quasi-Periodic and Chaotic States under a Non-Linear Control Law", by Francisco J. T. Salazar and Antonio B. A. Prado [7], studies the dynamics of a tethered satellite. It shows that when the length of the tether remains constant, the relative planar motion of the tethered sub satellite with respect to a base satellite, in a circular orbit around Earth, has two types of equilibrium points: local vertical and local horizontal positions, which are center and saddle points, respectively. It also shows that when three-dimensional motion is initially excited, the relative motion of the sub satellite shows quasi-periodic and chaotic behavior. In addition, a non-linear tension force that uses a Lyapunov approach is suggested to control the pitch–roll motion during the deployment and retrieval phases. The main goal is to guide the relative non-linear motion of the sub satellite to the local upward vertical position.

The paper "An Enhanced Calculation Method of the Heat Rejection System of a Free-Piston Stirling Engine (FPSE) Operating on the Moon", by Sergey Smirnov, Mikhail Sinkevich, Yuri Antipov, Igor Tsarkov, Sergei Kupreev and Hassan Khalife [8], proposes a method for a heat rejection system to operate on the moon. This method evaluates the capabilities of various refrigerants and chooses the main important aspects involved in designing this system: the radiator parameters and the refrigerant flow regime. The results show that when using liquid ammonia, more possibilities exist for varying the geometric parameters of the radiator. The use of liquid ammonia also reduced the power spent on pumping the refrigerant. Using helium, the power was 5.1 W during a turbulent flow, while the power required for pumping liquid ammonia was only 0.27 W. Another advantage of using liquid ammonia is that it increased the heat flux radiated by the radiator pipe by 3.9 times.

The paper "Lifetime and Dynamics of Natural Orbits around Titan", by Lucas S. Ferreira, Rafael Sfair and Antônio F. Bertachini A. Prado [9], studies natural orbits with longer lifetimes around Titan. The paper evaluated the effects coming from the gravity field of Saturn, the perturbative effects coming from the non-sphericity of Titan and atmospheric drag. Lifetime maps were generated for different initial configurations of the orbit, for different scenarios of orbital perturbations. The results showed the existence of orbits surviving for at least 20 years and conditions with shorter times, but long enough times to complete a mission, including the important polar orbits. The paper also proposes some orbits with minor oscillations in the altitude.

The paper "A Comparative Analysis of Different Strains of Coronavirus Based on Genometric Mappings", by Ivan V. Stepanyan and Michail Y. Lednev [10], comprises a mathematical study and identifies features in the genetic composition of the nucleotide sequences of various coronaviruses, using techniques that allowed for a comparison of the biochemical parameters of diverse RNA coronaviruses in a visual form. The results showed examples of different approaches to imaging the viruses. Several visualization types were used, such as structural, integral and frequency types. The paper also displayed the structure of RNA sequences of coronaviruses in spaces of various dimensions.

The paper "Trajectories Derived from Periodic Orbits around the Lagrangian Point L1 and Lunar Swing-Bys: Application in Transfers to Near-Earth Asteroids", by Rebeca S. Ribeiro, Cristiano F. de Melo and Antônio F. B. A. Prado [11], shows trajectories derived from the retrograde periodic orbits around the equilibrium point L1. The dynamics are based on the circular restricted three-body problem, the restricted bi-circular and the full four-body Sun–Earth–Moon-spacecraft. The periodic orbits found here are predicted using the CR3BP. Trajectories with slightly different increments of velocity from the ones needed to generate periodic orbits around L1 are applied to a spacecraft in a circular low Earth orbit. Therefore, translunar trajectories derived from the periodic orbits are obtained, which will take the spacecraft to the vicinity of the Moon. Three types of trajectories are found: collision with the Moon, escape and geocentric orbits with large semi-major axes.

The paper "Spectral Decomposition of Mappings of Molecular Genetic Information in the System Basis of Single Nucleotide Functions", by Ivan Stepanyan and Michail Lednev [12], shows examples of large amounts of genetic information using a new class of cognitive computer graphics algorithms. The paper creates a summary of algorithms for visualizing long nucleic acids based on the primary Hadamard–Walsh function system available. The method described in the paper allows the production of one-dimensional mappings of nucleic acids by levels corresponding to their scale-integral physicochemical parameters and the construction of a spectral decomposition of the nucleotide composition. An example of the spectral decomposition of parametric representations of molecular genetic structures is also shown, to better explain the method.

The paper "Mapping Long-Term Natural Orbits about Titania, a Satellite of Uranus", by Jadilene Xavier, Antônio Bertachini Prado, Silvia Giuliatti Winter and Andre Amarante [13], investigates the duration of polar circular orbits with low altitude around Titania. The paper presents the results of numerical simulations showing long-duration orbits. The gravity field of Titania is expanded up to second order and the gravitational perturbation of Uranus is also considered. A study of the effects of errors in the values of J2 and C22 in the lifetimes of the orbits is also conducted. The results indicate the existence of low-altitude near-circular orbits with longer lifetimes, which is very important for practical applications. The results also prove that non-zero values for the argument of periapsis and longitude of the ascending node can increase the lifetime of the orbits by up to eight times.

The paper "Swing-By Applications and Estimation of the Van Allen Belts' Radiation Exposure for a Spacecraft in a Low Thrust Transfer to the Moon", by Rodrigo N. Schmitt, Antonio F. B. A. Prado, Alexander Sukhanov and Vivian M. Gomes [14], studies the problem of how much radiation a spacecraft is subjected to in an Earth–Moon transfer. The spacecraft starts its motion in a low Earth orbit and uses electric propulsion to reach the Moon. In the first step, optimization is performed to find the locations and lengths of the thrust arcs that

maximize the final mass of the spacecraft for several transfer orbits. The Van Allen belts were modeled according to the density of electrons and protons to allow the measurement of the total radiation absorbed by the spacecraft. The results show the relationship between the fluency of the particles and the parameters of the mission, such as the initial eccentricity of the orbit and the propulsion system. An analysis of the effects of a swing-by maneuver is also included.

The paper "Hypothesis of Cyclic Structures of Pre- and Consciousness as a Transition in Neuron-like Graphs to a Special Type of Symmetry", by Vladimir Aristov and Ivan Stepanyan [15], proposed a statistical kinetic model to describe the pre-consciousness and consciousness structures based on the cognitive neural networks. The differences between the cycle parameters in the neural network models obtained can reach the thousands, or even more. These cluster and cyclic structures can be interpreted as the primary elements of consciousness and as a necessary condition for the effect of consciousness itself. The results presented are promising in neurocomputer interfaces, man–machine systems and artificial intelligence systems.

The paper "A Gain Scheduling Design Method of the Aero-Engine Fuel Servo Constant Pressure Valve with High Accuracy and Fast Response Ability", by Wenshuai Zhao, Xi Wang, Zhen Jiang and Yifu Long [16], develops a closed-loop disturbance rejection system of the constant pressure valve. The method is built using linear incremental description, where pressure is the object to be controlled. The linear models of the closed-loop system are also obtained. After this, the effects of the stabilization control gain on the dynamic performance and stability of the system are given. Then, a gain scheduling design method of the system is proposed. The results tell us that, even under unfavorable conditions, the method works very well.

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