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A hexagonal Interface Spacecraft Docking System

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Abstract

Hexagonal interface docking unit with new Euclidean support-guide legs which provide free relative motion of spacecrafts and their docking units are proposed. Kinematic schemes of soft capture interface extension, retraction and motion mechanism are described.

Keywords: Docking System; Structural Synthesis; Mobility; Euclidean Space; Kinematic Chain; SCS; HCS

Abbreviations: SCS: Soft Capture System; HCS: Hard Capture System; SCR: Soft Capture Ring; R: Revolute Joint, Scs: Spherical joint in cylindrical slot; DoF: Degree of Freedom

Introduction

Spacecraft docking in orbit is carried out by means of active and passive units. Each unit consists of SCS [1] and HCS [1]. These androgynous systems assembly in their turn consist of capture rings, guide petals, Euclidean extension, retraction and motion mechanism (comprised of three support-guide legs) with six degrees of freedom, [1] damper-separator springs, flat latch mechanisms and joint sealing mechanisms with corresponding actuators [2,3].

Mini Review of the Research

In proposed system the Euclidean six DoF support-guide legs extend, retract and provide motion of the hexagonal body of the active unit (SCR [1]). Three kinematic chains of 5RScs structure (spherical pair in the cylindrical slot has the form (RRR)P=Scs) connect the odd sides of hexagonal capture ring and docking unit (Figure 1). Closed kinematic circuits 5R create flat five-link mechanism with two degrees of freedom M=2, the connecting coupler point of which is connected to the hinge Scs. Also, three cushion springs, mounted parallel to the support-guide legs play the role of dampers during first contact and seperation system elements during undocking. Rectangular odd [1,3,5] buffer links of the active unit are in contact with the passive unit through the corresponding guide elements(petals) [2,4,6], which provide the reduction of linear and angular mismatches during axial convergence (Figure 2).The hexagonal shape of the unit also makes a contribution to the alignment, providing six “target” corner axes. Using two of them in conjunction with center axis will make alignment faster in theory.

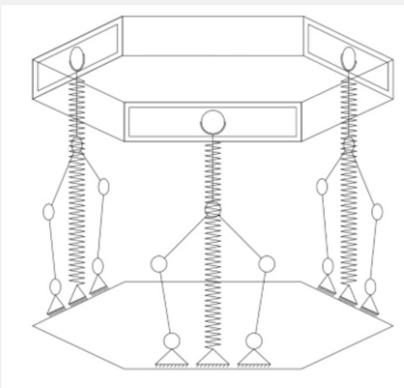

Figure 1: Kinematic scheme of the 6DoF spacecraft docking unit 3(5R) Sc.

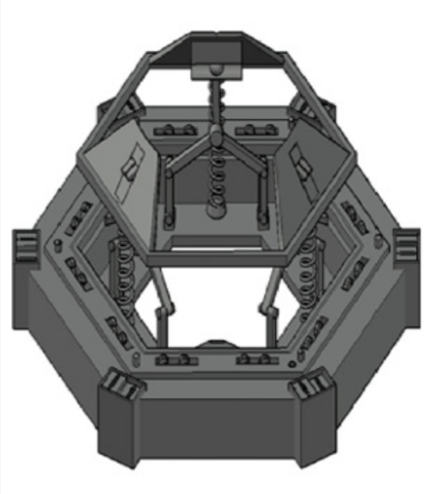

Figure 2: The 6DoF parallel soft capture ring of spacecraft docking unit.

The elements of locking and sealing mechanism hold the corresponding initial docking positions. At the end of the docking of the active Euclidean ring with the passive docking unit, the locking and sealing mechanisms are brought to the appropriate extreme positions. Flat latch mechanisms with one degree of mobility are installed on the buffer links of the docking manipulator. The latch mechanism is represented as a locking link, which is held by a spring. The approach, carried out at low speed, allows contact sensors to signal coupling. The latch mechanism is held by the force of the spring in its original position. At low speeds of convergence of the active unit to the passive one, the contact of the working surfaces of both (active and passive) buffer links is carried out. When the latch hits the free space, the spring returns it to its original position. Then the contact of the latch is carried out by its "reverse" surface, which provides no relative motion. The contacts of all the latches of the buffer links provide the primary mechanical coupling of the docking units.

Mathematical Model. Parallel Euclidean docking mechanism with $\lambda=6$, $\lambda_l=3$, $c_l=3$, M=6 is represented (Figure 1). The end effector (SCR) motion parameters: $\lambda=6$; the loop motion of the legs: $\lambda_l=3$; the total number of leg: $sc_l=3$; mobility of parallel docking mechanism: M=6.

Mobility equation for manipulators which contain mixed independent loops with variable general constraint can be calculated as

$$M=\sum_{i}^{j} f_i-\sum_{k=1}^{L}\lambda_k+q-j_p \quad (1)$$

Where: M – mobility of manipulator;

λ_k – the dimension of the active motion space;

L – the number of independent loops;

f_i – the DoF of kinetic pairs;

j – the number of joints;

q – the excessive over closing constraints;

j_p – the number of passive DoF in kinematic pairs.

The number of independent loops shown as:

$$L=C_l+C_b+C_h \quad (2)$$

where: $C=C_l+C_b+C_h$

Parameter C is the sum of legs, branches and hinges between mobile platforms.

The general structural formula for motion of end effector of serial-parallel Euclidean docking mechanism with variable general constraints can be given in the following form:

$$m=\lambda+C_l+C_h+\sum_{l=1}^{C_l}(d_i-D)+\sum_{j}^{n}(f\,|\,i-\lambda_b) \quad (3)$$

where: D=3 is dimensions of space R^3, d=2 for plane R^2.

By using Figure 1 and Eq.(1) total DoF and kind of kinematic pairs at the three legs can be calculated as

$$\sum_{k=1}^{5}\lambda_k=3.3+6.2=21$$

$$\sum f_i=5.3+4.3=27$$

M=27-21=6

So, we have 6 input parameters.

By using Eq.(3), the motion of platform of the moving Euclidean docking parallel manipulator can be defined as

m=6+3+0+(2-3)·3=6

The motion of the docking platform will be =6 : R_x,R_y,R_z,P_x,P_y,P_z.

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Conclusion

The problem of structural synthesis of Euclidean docking mechanism with variable general constaint of the legs and closed loops depends on the DoF and motion of an end effector(SCR). Two mobility equations were introduced for manipulator with mixed or fixed dimensions of close loops. The motion of end effector at docking manipulator with legs from different Euclidean planes were considered. New Euclidean 6 DoF parallel docking mechanism of spacecraft was synthesized.

References

1. Sean MK, Scott PC (2017) International Docking Standard (IDSS) Interface Definition Document (IDD). (NASA Johnson Space Center Houston, TX United States), Revision E, October 2016
2. Syromyatnikov VS (1984) Docking devices of spacecraft. M Mechanical Engineering, pp.216.
3. Rasim A (2019) Structural Synthesis of Robot Manipulators by Using Screw with Variable Pitch. Universal Journal of Mechanical Engineering 7(2): 50-63.
4. Rasim A, Cagdas B, Erkin G (2007) Structural Synthesis of serial platform manipulators. IFToMM J Mechanism and Machine Theory 42: 580-599.
5. Freudenstein F, Alizade R (1975) On the degree of freedom of mechanisms with variable general constraint, IV Word IFToMM Congress, England, UK, P. 51-56.
6. Alizade RI, Can FC, Gezgin E (2008) Structural synthesis of Euclidean platform robot manipulators with variable general constraints. IFToMM J Mech Mach Theory 43: 1431-1449.

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