Space science education by Mathematica demonstrations: interactive conceptual design for foldable and extendable structures for space applications

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Abstract

By the interactive Mathematica Demonstrations of the Wolfram Research instrumentation [1], various mechanics and space motion operation simulations of any spacecraft was studied. The authors created great number of Mathematica demonstrations which are available from the Wolfram Demonstration site.

Introduction: About Mathematica 6.0 version

The newest version of Mathematica appeared in 2007 May. Of its possibilities we used the interactively manipulating graphics for the movement modeling. A great number of parameters of the structure can be varied. By this parametrisation it can be demonstrated how can be built up, fold, extend, unfold, retract, etc. the structure. Using these possibilities newer and newer needs arise in connection with the spatial rearrangement of the structure. Stereoscopic view steps further, but can not go behind the object. The spatial motions and moreover the longer sections of the robotic representations can give an extended help in robotic motion planning. This serves students in space science education and in learning, too. Another benefit of this modelling that the relation between the parameters can be fitted, harmonized, counterbalanced and optimized during planning.

Foldable and extendable elements on space probes

Extending mechanical elements of the real space probes are the important topics where spacecraft motions can be shown with the Wolfram Mathematica demonstrations. First we mention the opening of a complex folded solar panel fixed on a cylinder arm (Fig. 1.), solar panel on probe body surface (Fig. 2.)

Fig. 1. Foldable complex folded solar panel fixed on a cylinder arm: http://demonstrations.wolfram.com/FoldablePanel/

Extendable variant of the Nuremberg scissors is the Astromesh, where the edge of the frame of a parabolic radio antenna is formed by the chain the “scissors” in a circular arrangement (Fig. 3.).

Fig. 2. Solar panels folded from the mantle of the prismatic space probe body (left) and opening sphere (right): http://demonstrations.wolfram.com/RotatingTheSidesOfARightRegularPrism/ http://demonstrations.wolfram.com/OpeningASphere/

Fig. 3. Astromesh, with circular Nuremberg scissors. http://demonstrations.wolfram.com/AstroMeshReflect or/

The most conventional radio antenna is an umbrella like segmented cone. However, umbrellas are important elements of various parachutes, too, which are basic in the recent landing systems on the Mars and also used at the Titan landing of Huygens probe of Cassini.

Fig. 4. Segmented traditional umbrella-antenna.
Fig. 5. Astromast antenna, with helical opening by remembering metal wires. Japanese inventor Koryo Miura used it first.

Fig. 6. Deployable segmental antenna has the benefit of wide range of spatial orientations, as shown by the demonstration:

http://demonstrations.wolfram.com/DeployingAndSteeringAParabolicAntenna/

Fig. 7. Extendable shelter: probably used in planning the lunar base.

http://demonstrations.wolfram.com/ExtendableShelter/

Fig. 8. Rhombic modeled space station

http://demonstrations.wolfram.com/GoldenOctetTruss/

**Rhombic system of space station construction**

As it was shown earlier the basic element of a golden rhombohedral system is capable to be a modular unit for both crystalline and spherical constructions (Fig. 8.). [6].

**Summary**

Space science education strongly builds on Math, Science and Technology skills of the students. The new Wolfram Mathematica Demonstrations program embraces both fields and helps them by visualization of simulations. Spatial motions are easily imaginable when they are shown by rotated and modified objects.

The interactive Mathematica Demonstrations of the Wolfram Research help planning instrumentation, mechatronics and field operation simulations of space probes as it was shown here mostly for deployable antennas and solar panels [8].

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**References**


