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Optimization of two-dimensional Deployment Trajectory of Solar Panels in Space Solar Power Station

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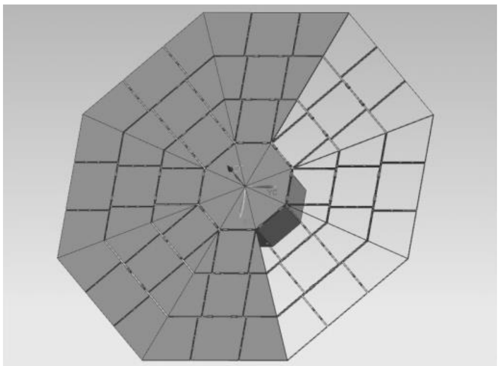
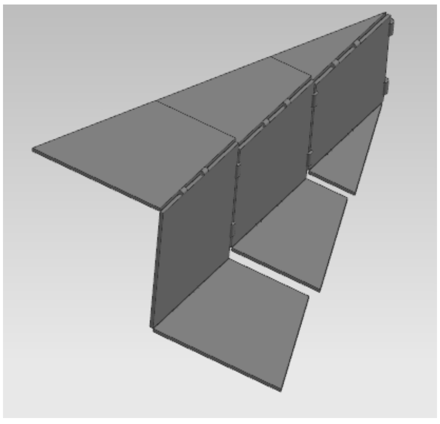
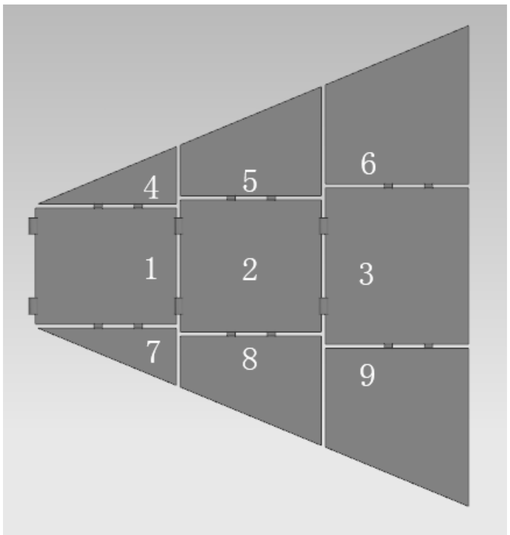
1. Introduction

The maximum length of the abstract is two pages in A4 size. This paper proposes a method to optimize the two-dimensional deployment trajectory of solar panels in space solar power station (SSPS) by using genetic algorithm (GA). The proposed objective function of the GA is to minimizing the deployment time and space without any collision of the solar panels with the space solar power station body, while not exceeding the maximum predetermined torque. Quadrinomial and quintic polynomials are used to describe the segments that connect initial, intermediate, and final point at joint-space. Finally, a simplified experimental platform has been set up, and the experimental results verify the two-dimensional deployment trajectory of solar panels after genetic algorithm optimization.

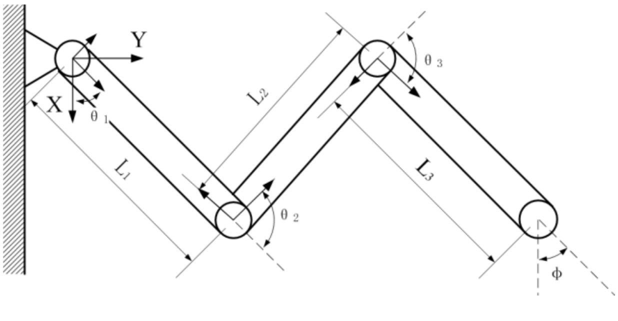
2. 2-D deployment of solar panels in SSPS.







3. Kinematic Equations and Trajectory Planning



$$x = l_1 \cos\theta_1 + l_2 \cos(\theta_1+\theta_2) + l_3 \cos(\theta_1+\theta_2+\theta_3) \quad (1)$$

$$y = l_1 \sin\theta_1 + l_2 \sin(\theta_1+\theta_2) + l_3 \sin(\theta_1+\theta_2+\theta_3) \quad (2)$$

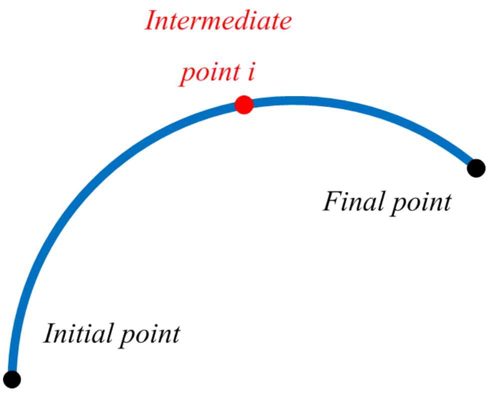
$$\phi = \theta_1 + \theta_2 + \theta_3 \quad (3)$$

$$\theta_2 = a\tan 2(\sin\theta_2, \cos\theta_2) \quad (4)$$

$$\theta_1 = \operatorname{atan2}\begin{pmatrix} y_n\left(l_1 + l_2\cos\theta_2\right) - x_n l_2 \sin\theta_2 \\ x_n\left(l_1 + l_2\cos\theta_2\right) + y_n l_2 \sin\theta_2 \end{pmatrix} \quad (5)$$

$$\theta_3 = \phi - \left(\theta_1 + \theta_2\right) \quad (6)$$

4. Trajectory planning strategy



$$\theta_{i,i+1}(t) = a_{i0} + a_{i1}t_i + a_{i2}t_i^2 + a_{i3}t_i^3 + a_{i4}t_i^4, \left(i = 0, \cdots, m_p - 1\right) \quad (7)$$

Where $(a_{i0}, \ldots, a_{i4})$ are constants, and the constraint are given as:

$$\theta_i = a_{i0} \quad (8)$$

$$\theta_{i+1} = a_{i0} + a_{i1}T_i + a_{i2}T_i^2 + a_{i3}T_i^3 + a_{i4}T_i^4 \quad (9)$$

$$\dot{\theta}_i = a_{i1} \quad (10)$$

$$\dot{\theta}_{i+1} = a_{i1} + 2a_{i2}T_i + 3a_{i3}T_i^2 + 4a_{i4}T_i^3 \quad (11)$$

$$\ddot{\theta}_i = 2a_{i2} \quad (12)$$

Where T_i is the execution time from point i to point $i+1$. The five unknowns can be solved as:

$$a_{i0} = \theta_i \quad (13)$$

$$a_{i1} = \dot{\theta}_i \quad (14)$$

$$a_{i2} = \frac{\ddot{\theta}_i}{2} \quad (15)$$

$$a_{i3} = \frac{\left(4\theta_{i+1} - \dot{\theta}_{i+1}T_i - 4\theta_i - 3\dot{\theta}_i T_i - \ddot{\theta}_i T_i^2\right)}{T_i^3} \quad (16)$$

$$a_{i4} = \frac{\left(\dot{\theta}_{i+1}T_i - 3\theta_{i+1} + 3\theta_i + 2\dot{\theta}_i T_i + \frac{\ddot{\theta}_i T_i^2}{2}\right)}{T_i^4} \quad (17)$$

The intermediate point $(i+1)$'s acceleration can be obtained as:

$$\ddot{\theta}_{i+1} = 2a_{i2} + 6a_{i3}T_i + 12a_{i4}T_i^2 \quad (18)$$

The segment between the number m_p of intermediate points and the final point can be described by quantic polynomial as:

$$\theta_{i,i+1}(t) = b_{i0} + b_{i1}t_i + b_{i2}t_i^2 + b_{i3}t_i^3 + b_{i4}t_i^4 + b_{i5}t_i^5, \left(i = m_p\right) \quad (19)$$

Where the constants are given as:

$$\theta_i = b_{i0}$$

$$\theta_{i+1} = b_{i0} + b_{i1}T_i + b_{i2}T_i^2 + b_{i3}T_i^3 + b_{i4}T_i^4 + b_{i5}T_i^5$$

$$\dot{\theta}_i = b_{i1}$$

$$\dot{\theta}_{i+1} = b_{i1} + 2b_{i2}T_i + 3b_{i3}T_i^2 + 4b_{i4}T_i^3 + 5b_{i5}T_i^4 \quad (23)$$

$$\ddot{\theta}_i = 2b_{i2} \quad (24)$$

$$\ddot{\theta}_{i+1} = 2b_{i2} + 6b_{i3}T_i + 12b_{i4}T_i^2 + 20b_{i5}T_i^3 \quad (25)$$

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