Designing an Earth Through Satellite Viewing Simulator with Useful Application

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ABSTRACT: Today human living is affected by satellite expansively. For example in meteorology, topography, photography, communication and other application. Precision of satellite photography depend on precision of satellite attitude and satellite position and satellite photography timing accuracy. For satisfying this aim could use satellite simulator and determinate photography area using it. Satellite simulator is software that gives satellite trace and satellite local timing. This software could obtain area and timing for photography and apply them to real mission. In this paper, designing of a satellite simulator (ASRASAT) and definition of its application have been investigated.
Keyword- Satellite simulator, Software, photography, Kepler, Transfer matrix, Motion trajectory.

1. Introduction

Using software simulator is applied today to predict satellite position. One of the aims of satellite simulator is determining photography areas. If time and area of photography using satellite simulator is obtained, satellite software for accuracy photography will obtain[1,2]. For determining area and its time for photography, initially location of satellite on space at standard time or local time should be determined. For obtaining this aim, kepler equation should be solved and then using rotational matrix, the location of satellite on space is acquired. Continuing the methods that solve kepler equation investigated and designing of simulator is considered.

2. Dissolution of Kepler Equation

When a body is circulated around the other body in space, motion trajectory almost is ellipse. Motion trajectory is presented by Kepler equation. Kepler equation and its resolve is as follow.

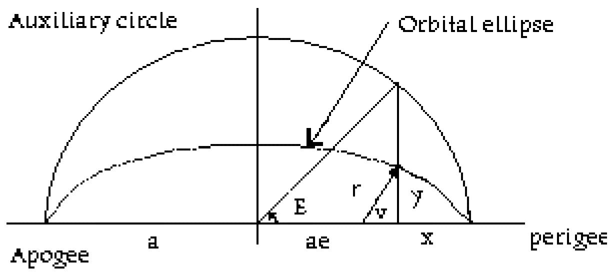

Fig. 2.1. Tracking in ellipse orbit

$$
\begin{aligned}
&E(t) - e\sin E(t) = M \\
&r = a(1 - e\cos E) \\
&x = a(\cos E - e) \\
&y = a(1 - e^2)^{.5}\sin E
\end{aligned}
\quad (2.1)
$$

An example of two line element for some satellites have been presented as follow [4,5].

COSMOS 1602
1 15331U 84105A   05061.93211085 .00000780 00000-0 60201-4 0 6740
2 15331 82.5313 342.2993 0016161 123.8498 236.4266 15.00100370106956
SPOT 1
1 16613U 86019A   05061.78248675 .00000277 00000-0 59699-4 0 3778
2 16613 98.6441 164.7164 0152966 206.9675 152.3517 14.60250428673567

In the " EQ. (2.1) " M is mean Anomaly (the amount between 0 to 360) and e is eccentricity of orbit and E is eccentric anomaly[6]. In this problem M and a and e in definite and E is indefinite. Different methods for solving this problem have been presented. Usually an iterative method (for example Newton method) for solving this problem is helped. After solving this problem and using space geometry we can determine position of satellite in space. In practice for determining space geometric use two line elements. In two line elements full characteristic of orbit in space have been specified. Distribution of atmosphere, radiation, and moon affect on moving satellite on orbit. In two line element exist parameters for calculating affection of disturbation. Drag parameter in two line element have three members by the name xdot/2 xdotdot/6 and bstar. This three parameters present atmosphere and star disturbation. Drag oneself present half deravation from mean motion.

3. Designing of Simulator

For designing simulator at first should solve kepler equation and then by helping rotation matrices , the position of satellite in space should acquire. The rotation matrices for solving this problem are as follow[8]:

$\mathbf{A}_1$=Rotation matrix in terms of orbit coordination system to earth changeable inertia coordination system;
$\mathbf{A}_2$=Rotation matrix in terms of earth changeable inertia coordination system to earth inertia coordination system.
$\mathbf{A}_3$ = Rotation matrix in terms of effecting the movement of ellipse in orbit plane.
$\mathbf{A}_4$ = Rotation matrix in terms of inclination angle.
$\mathbf{A}_5$ = Rotation matrix in terms of Right Assent ion of Ascending Node.
$\mathbf{A}_6$ = Rotation matrix in terms of Argument of pirogue.
A= Multiplication of all matrices.
X=Position of satellite on ellipse.

$\mathbf{A}=\mathbf{A}_6.\mathbf{A}_5.\mathbf{A}_4.\mathbf{A}_3.\mathbf{A}_2.\mathbf{A}_1.\mathbf{X}$

An example of data from asrasat simulator has been presented as follow:

20050321	011313	249.999691302521	-103.182165918604	0.984806245202423
20050321	011328	249.999691302519	-103.070665186716	1.96897461480319
20050321	011343	249.999691302522	-102.958959219559	2.95312488977222
20050321	011358	249.999691302522	-102.846944834954	3.93724797239448
20050321	011413	249.999691302521	-102.734518130871	4.92133470073004

In the above result, the first column is the date, the second column is the time, the third column is the altitude(KM) of Satellite , the forth column is the longitude of satellite, the fifth column is the latitude of satellite[3].

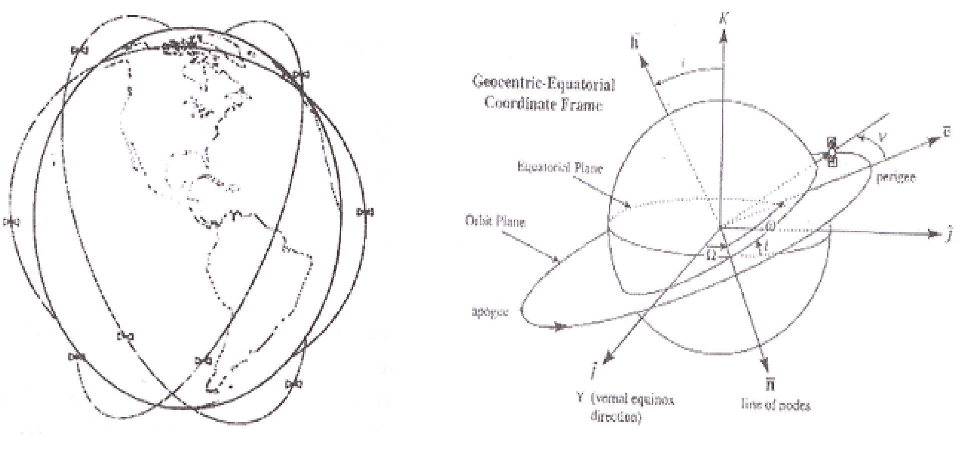

Fig . 3.1. Satellite orbit with its parameters

After determination satellite position in space, the footprint of satellite on earth surface should be determined. For achieving this aim, the latitude and longitude of satellite at each time should be located on expanded map of earth at same time.

4. Presentation of Special Orbit

If the said above materials is fulfilled, the simulator of satellite will produce. After all, if the circle proportion to seen area from satellite around footprint of satellite on earth is drowned, the area for photography from satellite at each time will acquire. The radio of this circle area is obtained as follow[6]:

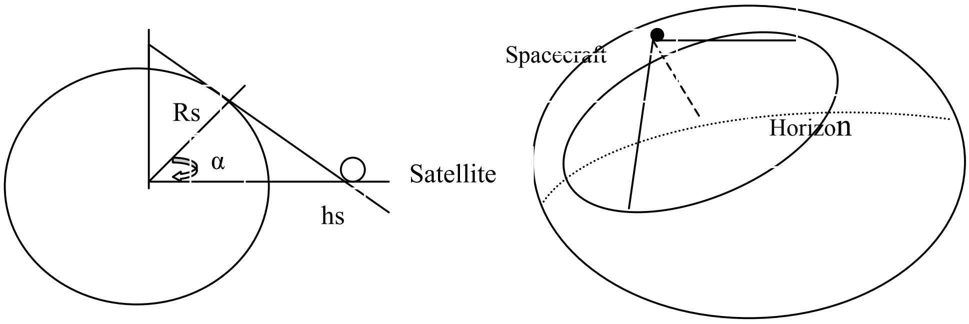

Fig . 4.1. Viewed area from Satellite

$$Cos\ (\alpha) = \frac{R_S}{R_S + h_S} \qquad (4.1)$$

In this formula R_S is earth radius and h_S is altitude of satellite and α is viewed arc from satellite.

In continuing, the result of designed simulator will be presented. The first presentation of simulator concerning to orbit with following parameters.

Inclination=40 Degree (Angle between equator plane and orbit plane)
RAAN=220 Degree (Angle between spring equinox point and center of earth and satellite point)
AP=0; (Angle between perigee point and center of earth and ascending node)
MA=0; (Angle between satellite and center of earth and perigee point)
MM=16; (Number of the satellite rotations around earth at 24 hours)
PTI =10 min; (Photography time interval from satellite)
The graphically result of simulator is as follow.

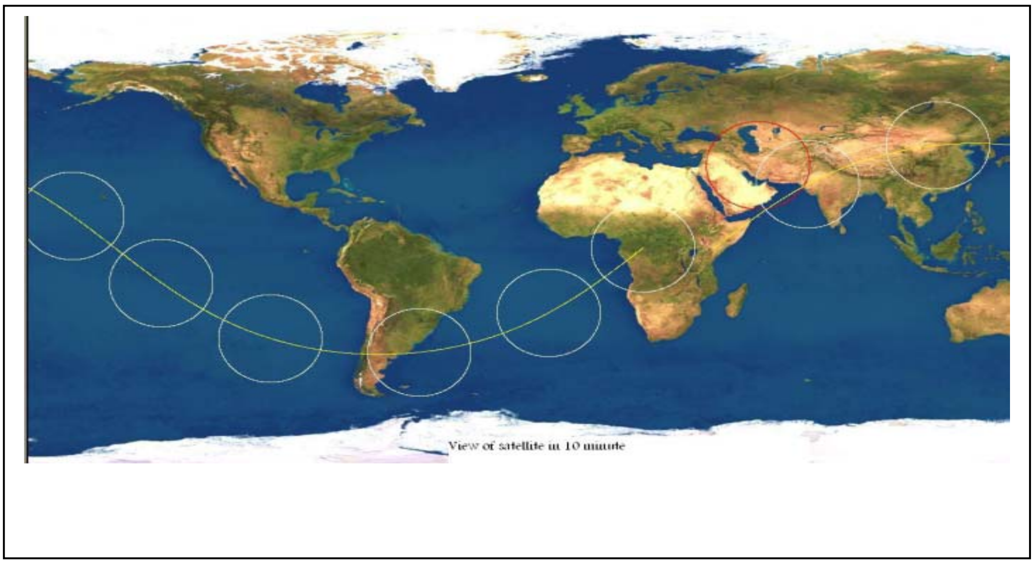

Fig. 4.2. Circle orbit with 40^o inclination and 1.5h period and 10 minute photography

As above seen by this time interval, 9 area pictures from different locations have been photographed. For example INDIES is located at the first photo. Using this simulator we could determine photography position and time for photography from satellite at each orbit. At the second photo , photography with 2.5 minute time interval has been fulfilled. By this photography almost an area adapted to satellite trajectory is obtained[8].

Fig. 4.3. circle orbit with both 40^o inclination and 1.5h period as well as 2.5 minute photography

When broad communication area is necessary, the ellipse orbit is used. By employing suchlike orbits could observer the satellite for long time. For example if the orbit is molniya with 15.4h period, the satellite could observe more than 12h in each period from particle point. This specialty in communication is used because for long time could communicate between two point around the satellite footprint. At the next photo, the molnia orbit has been presented. In this orbit through IRAN the satellite could be seen expensively[9].

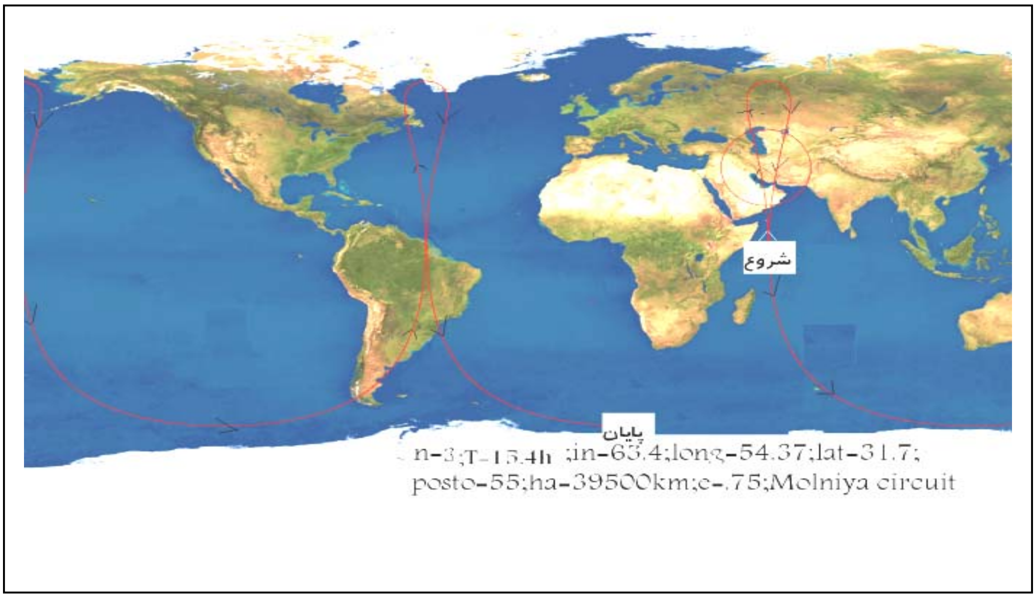

Fig. 4.4. mylnia orbit with both 63.4^o inclination and 15.4h period

At the next photo the orbit of satellite for broad communication has been designed. The spicefication of orbit are as follow [7]:

Inclination= 40 degree,Eccentricity=.5;RAAN=160 degree;AP=0 degree;MA=0 degree;MM=5;

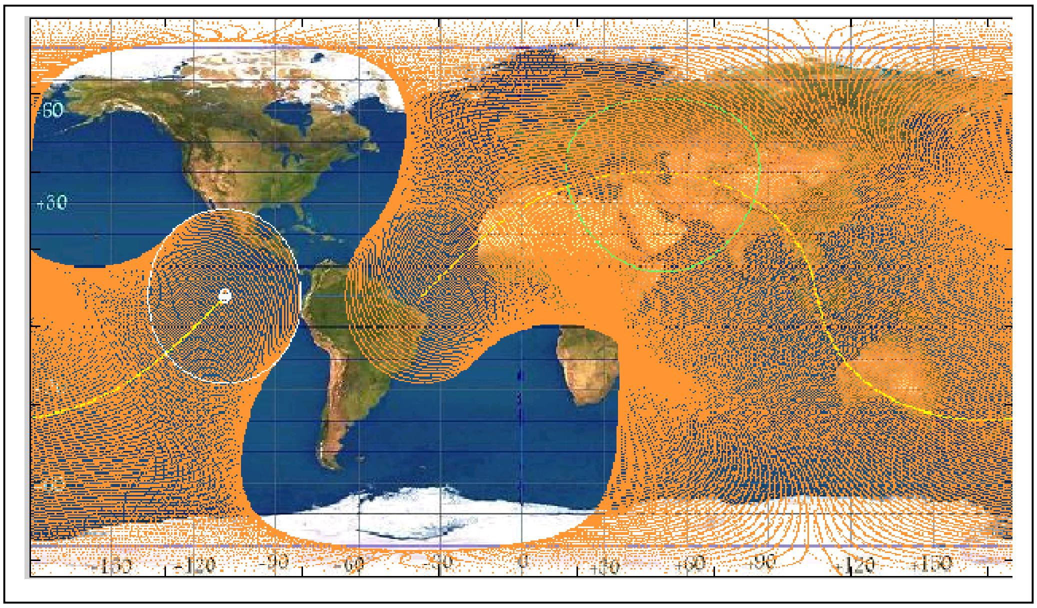

Figure 4.5. Communication orbit with both 40° inclination and 5 MM and RAAN=160 and e=.5

As above seen for one period of satellite orbit, 3/4 of the world is under communication cover.

5. Result

By designing and helping earth station simulator ,the position of satellite at each time could be obtained. By the aids of this informations the photography area for different missions could be acquired. This simulator could be used for determining the satellite orbit for broad comunication. Fortunatly in IRAN this simulator has been designed and for different aims is used.

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