In the first model, we need one sun-tracking camera and one normal camera.

1. Solve the coordinate of the center of a specific cloud.

Use the normal camera to take one picture of the sky. Record the position vector of the normal camera as . Mark and record the cloud block in the center of the photo. Record the direction vector as .

Put the sun-tracking camera in another position and record the position vector as Use the sun-tracking camera to take another photo to the same area of sky. Analyze the picture in each block and search out the marked cloud block. Adjust the picturing angle of the camera to make the marked cloud block at the center of the photo as well. Record the direction vector as .

Now we can use Formula 1 to solve the length of and.

(1)

Then we can solve the coordinate of the center of marked cloud block as , as Formula 2.

(2)

1. mapping to solar farms

Use the sun tracking camera to take two consecutive frames as the sun in the middle of the picture. Record the direction vector as . Analyze the whole picture and find out the specific cloud block and record down. Since the camera is a sun-tracking one, we can assume that the sunlight to the camera is vertical to the photo plane. We can calculate the H’ =.

According to the focal parameter of the sun-tracking camera, we can convert it in to the largest angle it can reach. We can convert it in to angle as the chart below.

|  |  |  |  |
| --- | --- | --- | --- |
| focal/mm | Max angle/° | focal/mm | Max angle/° |
| 15 | 180 | 100 | 24 |
| 14 | 114 | 135 | 18 |
| 20 | 94 | 200 | 12 |
| 24 | 84 | 300 | 8.25 |
| 28 | 75 | 400 | 6.1667 |
| 35 | 63 | 500 | 5 |
| 50 | 46 | 600 | 4.1667 |
| 70 | 34 | 800 | 0.0833 |
| 85 | 28.5 |  |  |

The angle α between the specific cloud block to sun-tracking camera and sun to sun-tracking camera is tanα =

β is the half angle of the camera’s largest angle,

a is the pixel in the picture between the center to the horizontal edge,

photo\_cloud is the position of the center of the specific cloud block

photo\_sun is the position of the center of the picture

The true distance between the cloud and sun is s = H’\*tanα.

Therefore, the ratio ρ of the true distance in the sky to the pixels in the picture is that ρ=, the unit is meter per pixel

Besides, the dihedral angle γ between the plane of the picture and the ground is

In the plane of cloud, the coordinate of the sun is

Now, we can get other coordinate of the center of other cloud blocks.

(Cx, Cy, Cz) = (sun’x+row\*ρ, sun’y +col\*ρ\*cosγ, sun’z)

As a result, we can calculate the position of the shading on the ground as below:

(sun’x+row\*ρ, sun’y +col\*ρ\*cosγ, 0)

