CalculateHeightFromShadow: A Stand-alone Program for Calculating Object Heights from GoogleEarth

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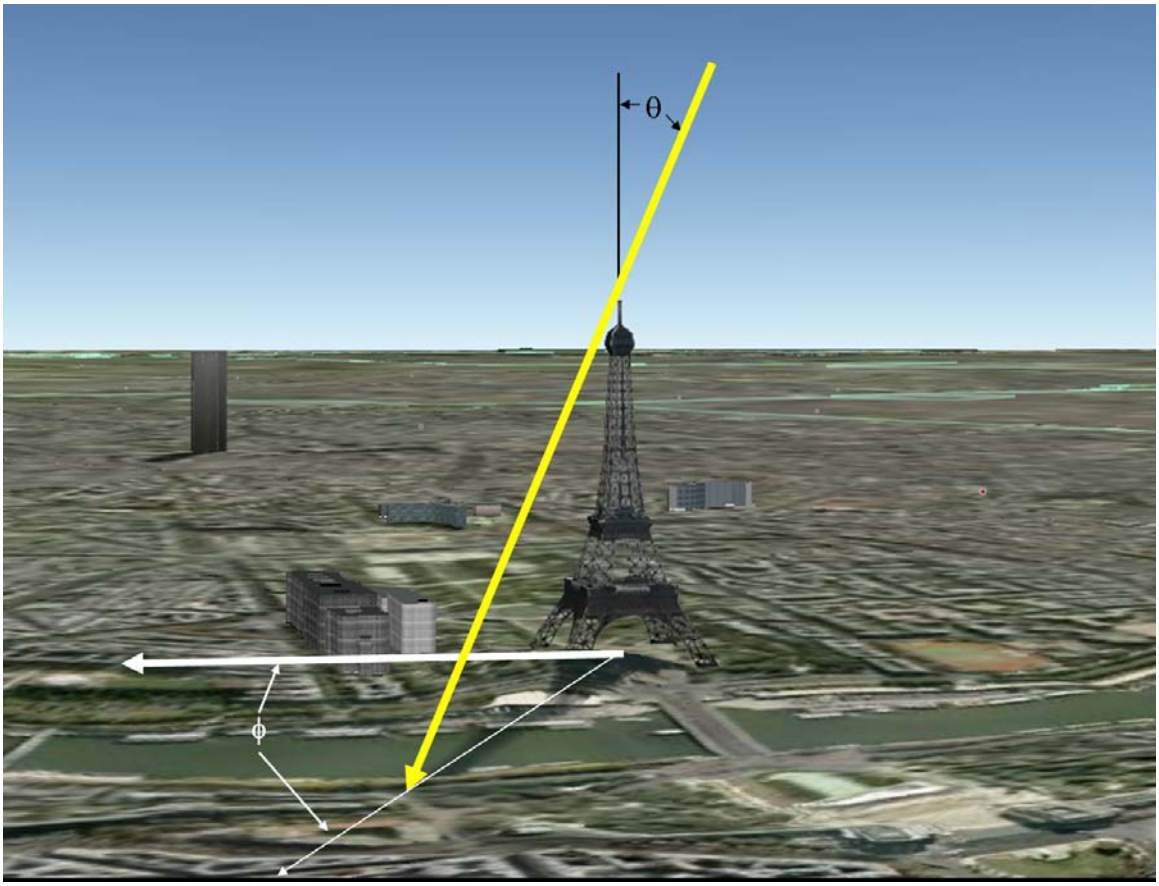

Figure 1. The sun's rays, shown as the yellow arrow, determines the length of the shadow. The sun's zenith angle, θ, is drawn from the vertical to this ray. The shadow's heading, ϕ, is measured from North to the object's shadow. Positive headings are clockwise from North; the one shown is -12°, negative because it is counter-clockwise from North. (This is GoogleEarth's nomenclature.)

1) Introduction

GoogleEarth has proven to be an important program for nongovernmental organizations to keep track of a variety of activities including the proliferation of weapons of mass destruction. Until now, however, its quantitative capabilities have been limited to calculating horizontal distances. For what ever its reasons, Google has resisted giving key information that would allow users to use shadow lengths to calculate object heights; in particular, Google has not provided a time stamp for scenes viewed with GoogleEarth. This was partially due to the nature of GoogleEarth, which shows a mosaic of satellite and other images, taken on different dates and different times, and knitted together to form a more or less seamless whole.

Recent versions of GoogleEarth, however, now show a date stamp of scenes that are close enough to the Earth's surface for the scene seen on a screen to come from a single image. (This date is shown in the bottom right hand border of the scene. Some of the older images only show the year it was taken and some only show the year and the month.) Fortunately, if the day, month and year are given, it is possible to use the compass heading of the shadow itself to determine the effective local "time", much like a sun dial can be used to determine the time at a given position. CalculateHeightFromShadow uses this heading, together with the latitude, longitude, and date of the scene, to determine the Sun's elevation and from that to return the length of the object being studied.

2) Installing calculatingHeigthFromShadow

This program runs on Windows computers and is only known to run on Windows XP (my operating system). It might run on other versions of Windows, I just don't know.

Down load the installer file from the website: http://mit.edu/stgs/downloads.html
This program uses the MATLAB runtime library, which because of space limitations on this website, is NOT included in the build file. You MUST already have installed the program GUI_missileFlyout since that build file installs the MATLAB runtime library. You must install this file in the same path as the MATLAB runtime library. (The simplest what of insuring that is to put it in the same directory as GUI_missileFlyout.)

Double click on the file calculateHeightFromShadow_pkg.exe The program will then extract all the needed files. Run the program by running calculateHeightFromShadow.exe.

3) Step-by-step Instructions

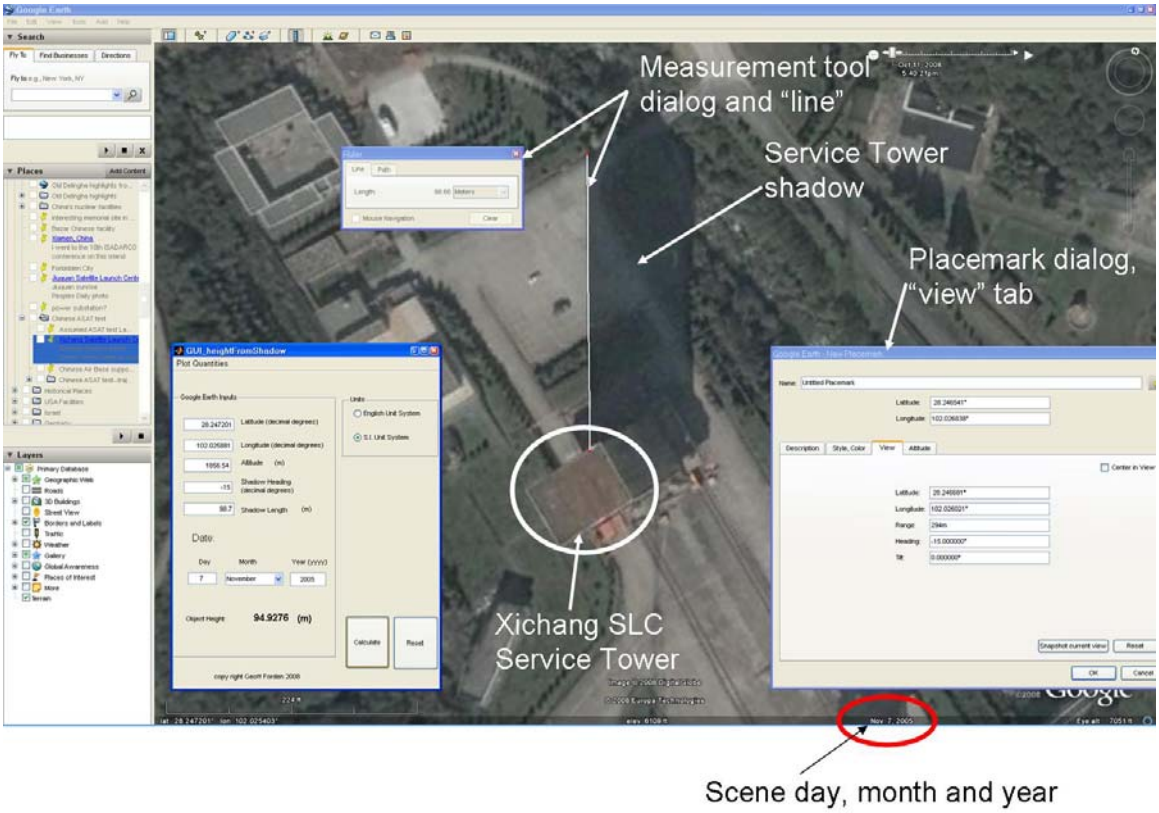

Figure 2. Illustration of the use of the program, calculateHeightFromShadow. In this illustration, the height of the Xichang Satellite Launch Center's Service Tower for Launch Pad #1 is shown. See the text for a step by step set of instructions for how to use the program.

Step 1) Zoom in on the object whose height you want to measure in GoogleEarth. It must have a date stamp associated with it that includes the day, month, and year. (See Figure 2 for the position of this date stamp as well as other quantities that must be measured.)

Step 2) Use the measurement tool to draw a line from the object base to the shadow end. Select either meters or feet for the units. The positioning of these two ends is the most important determination of the accuracy of the measurement! The next section will discuss potential systematic errors associated with this.

Step 3) Use the GoogleEarth navigation toolbar to turn the scene so that the line drawn in Step 2 is pointed due North (i.e. the base of the object to be measured is to the South of the line drawn and the tip of the shadow is directly North of the base.)

Step 4) create a placemark near the object, open the placemark's properties dialog and click on the "view" tab. Copy and paste the Latitude, Longitude and "Heading" into the calculateHeightFromShadow panel. Set the date on the calculateHeightFromShadow panel to the date shown on the scene date stamp.

Step 5) Be sure to select the proper units in calculateHeightFromShadow to match the units you use in GoogleEarth. Enter the shadow length into the calculateHeightFromShadow panel and the altitude of the object. (Note, current calculateHeightFromShadow does not use this altitude to make the corresponding small correction to the height calculation. A future version of the program will incorporate this.)

Step 6) Press Calculate and read off the height of the object. Note that you can print out all the quantities measured and calculated by the pull down menu: Output ➔ Print Results.

4) Systematic Problems in Measuring Shadow Lengths

Drawing the line from the object to the end of the shadow is the most important source of error in this measurement. There are several possible sources for this error:

a) Difficulties in finding the right starting point for the shadow. Because the satellite is not directly over the object being measured, the start point of the shadow might not be visible and has to be "guessed." For instance, in Figure 2 the Service Tower itself obscures the proper starting point is probably the reason why I measure 95 m height when the stated height is 100 m.

b) Uneven terrain at the shadow terminus. Buildings at the end of the shadow can substantially reduce measured length. This is undoubtedly why my measurement of the Eiffel Tower length (I measure 270 m while the Tower's height, without the radio tower on top, which I don't see in the shadow, is 300 m) is lower than expected. Also, note the "curving" of the Service Tower Shadow's northern most corner, which is undoubtedly due to a slight slope at that point. Clearly, the measurement of the shadow length using that corner would be artificially long.

c) Problems with GoogleEarth's date stamp. This is an empirical observation on my part and is far from certain. Sometimes, when I have looked at landmarks in Western cities that have many images making up a scene, the date stamp does not seem to accurate: it yields impossible heights for things like the St. Louis Gateway Arch (which is admittedly very hard to measure because of its curved shape). I can only conclude that GoogleEarth's date stamp is wrong for some of these scenes and that this is why Google does not want to give a full time stamp for a scene. More information of this would be very interesting.