



Mobile Sun Compass

Operating Instructions (beta release 5.0)

The ENEA Mobile Sun Compass is an application for Android smartphones whose main function is to determine the direction of the geographic North with high accuracy by recognizing the direction of view of the Sun and calculating ephemeris. Thanks to this ability, the app can be used for numerous other functions. The app consists of an introduction screen and 3 main screens. The various screens and the functions are explained in detail below.

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Screens


Introduction

It opens as soon as the application is launched and shows the installed version. To continue, press the message "PRESS TO START" . On the upper toolbar there is the title, a credits button and an exit button.


Functional screen


It is accessed directly from the introduction screen and is used for all the functions in which the measurement of the North direction is required. For each function there are small graphic differences but there is always the image of a wind rose in the center and, at the top, the indications of Greenwich Mean Time, the coordinates of the place, the azimuth and the elevation of the Sun.

Settings


It is accessed from the functional screen or from the ephemeris screen by pressing the icon  at the top right. On this page you can set the various parameters for using the app and display preferences.








Ephemeris

It is accessed from the functional screen by pressing the icon  in the top row. This page lists the values of the calculated ephemeris and it is possible to determine the time and azimuth of sunrise or sunset or the day and time in which the Sun transits in a particular position in the sky.

Information screen (currently only in Italian): accessed via the button .

FUNCTIONS

The ENEA Mobile Sun Compass performs several functions which can be accessed from the screen functional by pressing the icon  at the top left. The functions are as follows:

 Orientation	 Route direction	 Antenna installation	 Solar panel installation
 UTM orientation	 Wall azimuth detecting		 Magnetic declination measurement

Orientation

It is used to indicate the north direction with respect to the major axis of the mobile phone. As soon as the GPS has provided Greenwich Mean Time and the coordinates of the place, the app calculates the ephemeris and the North direction. For this calculation, the app must measure the direction of view of the Sun and to do this, one of the following 4 methods must be selected on the settings page.

FIXED METHOD

The user must rotate the Sun-Shadow line, that is superimposed on the image of the wind rose, towards the Sun. To do this, just touch on the words "Tap HERE to change Sun direction" and, in the screen that appears, drag the Sun icon towards the direction from which the sun's rays come. It is also possible to choose the 4 main directions or have the mobile pointing north, by selecting the appropriate buttons. Pressing on the writing at the bottom takes you back to the previous screen where, at the bottom, the

direction of the North is given with respect to the major axis of the mobile phone. By clicking on the writing at the bottom "NORTH AT ..." the azimuth with respect to the South rather than the North is provided.

"PARKING" function: when using the FIXED method in the 'Orientation' function, by pressing the FREEZE button it is possible to see the position that the Sun will have at various times of the day, useful information in particular to determine where to park the car in such a way to find it in the shade. The position of the azimuth of the Sun is indicated with numbers, which represent the hour, within the drawing of the wind rose, with a distance from the center proportional to the height above the horizon. The hours in which the Sun is on the horizon line, or even below, are indicated with inverted colors. By pressing on any of the hours marked, a message provides the exact elevation, in degrees, at that time.

GNOMON METHOD

When using this method, the user must frame, with the phone camera, the shadow of a vertical pole on the horizontal plane. The scene framed by the phone (which must be kept as horizontal as possible) is shown in the box at the bottom right. When the image consists of a sharp shadow in a bright field, the app deduces the direction of the sun's rays, reports the value (in green) above the box and draws a green line that traces the shadow. If this line is consistent with the direction of the shadow, it means that there were no errors in the measurement and therefore the data provided by the app is reliable. The direction of the North is indicated on the writing at the bottom, under the wind rose.

SHADOW METHOD

When using this method, the user must frame, with the phone camera, the shadow that the edge of a building projects on the horizontal plane. The scene framed by the phone (which must be kept as horizontal as possible) is shown in the box at the bottom right. When the image is made up of about half of the frame in shadow and half in light, the app deduces the direction of the sun's rays, reports its value (in green) above the frame and draws a green line that traces the shadow-light edge. If this line is consistent with the direction of the light / shadow dividing line, it means that there were no errors in the measurement and therefore the data provided by the app is reliable. The direction of the North is indicated on the writing at the bottom, under the wind rose.


SLIT METHOD

This method is the one that guarantees the greatest accuracy. To use this method, a box (plastic or cardboard) in which a slit of about 2 mm has been made on a vertical wall, must be placed under the camera lens. By orienting the slit towards the Sun, a line of light will form on the floor of the box which, when framed by the camera, allows you to determine the direction of view of the Sun. When the image is considered acceptable by the software, the angle that the line of light forms with respect to the Y-axis of the frame is measured, reports the value (in green) above the frame and draws a green line that traces the light line. If this line is consistent with the direction of the line of light, it means that there were no errors in the measurement and therefore the data provided by the app is reliable. The direction of the North is indicated on the writing at the bottom, under the wind rose. It should be remembered that the accuracy of the measurement strongly depends on the parallelism between the floor of the box and the mobile phone, on the verticality of the slit and the sharpness of its contours. With this method it is not necessary to keep the mobile phone in a horizontal position as long as the use of the phone's internal accelerometer is enabled in the settings page. When using this method to make high-precision surveys, it is good to take into account any misalignments due to the imperfect orientation of the sensor of the mobile phone camera or of the system used to create the line of light. If the misalignment value is known, it can be entered in the 'calibration parameter' (see the Settings section) and this value is automatically subtracted by the software. This parameter is taken into account only if the SLIT method is used.

NOTE (it holds for all methods except FIXED)

In the settings page, the accuracy of the calculation can be selected on 3 levels. This depends on the quality of the image taken by the camera. A low level of accuracy does not require an extremely sharp image, while a high level requires that the image has no ambiguities or sources of error. Above the frame of the image taken by the camera there is an inscription indicating whether the app has not detected any line ("No line") or if the image is not sufficiently defined ("Prec. Err." Or "NaN Err.") depending on the chosen accuracy. When the calculation is successful, the writing turns green, indicating the inclination of the detected line. As long as this calculation is not concluded positively, the image of the wind rose is drawn in very light colors. At the end of a correct calculation, the image becomes colored and contrasted.

Route direction ▲

This function has the purpose of indicating the direction to follow to reach or point to a predetermined place. To do this, it uses the calculation of the North direction in the same way as the "Orientation" function. The user must set the coordinates of the place to reach (or point to) by clicking on the icon  and choose one of the 4 proposed methods. When the app has calculated the North direction, a yellow arrow appears on the compass indicating the direction towards the target, the angle that this direction makes with respect to the North and its distance.

Antenna installation 📡

This function is used to correctly point a dish towards a given satellite.

To do this, it uses the calculation of the North direction in the same way as the "Orientation" function.

The user must choose the satellite to target using the icon .

Some satellites are already listed and can be selected by clicking on them, otherwise press the "+" key at the bottom right and manually enter the name and latitude of the satellite.

When the app has calculated the North direction, a yellow arrow appears indicating the direction in which to point the dish (with respect to the North) and the inclination value of the dish with respect to the vertical plane.

UTM orientation 📍

This feature is useful for civil engineers and surveyors. The output of this page is similar to that of the "Orientation" function but the azimuth and North direction indications refer to the UTM meridian and not to the geographic meridian. The UTM meridians are parallel to the central meridian of the time zone therefore they differ from the geographic meridians for an angle of convergence that depends on the latitude and the distance from the central meridian. On the page dedicated to this function, in addition to the North, the convergence angle and the zone code are indicated according to the subdivision of the UTM grid.

Wall azimuth detecting ↑

This function allows you to measure the direction in which the horizontal axis of a wall or its perpendicular points.

To do this, it uses the calculation of the North direction in the same way as the "Orientation" function.

To detect the azimuth of interest, simply point the mobile phone towards the wall, keeping it perpendicular or align it with the wall itself. Once the data of the North direction has been obtained, the azimuth of the 4 main directions is indicated and that one of interest can be obtained according to the position chosen by the mobile phone with respect to the wall.

Magnetic declination ↗

This function allows you to know the angle between the direction of the geographic North and that of the magnetic North (called "magnetic declination"). For this function it is essential that the mobile phone is equipped with a magnetic sensor. This function uses the calculation of the North direction in the same way as the "Orientation" function. As soon as the app has obtained the direction of geographic North, a yellow arrow appears on the compass indicating the direction of magnetic north and the angle it forms with the direction of true north.

SETTINGS PAGE

This page consists of 3 sections

Settings: upper section

Here is the date and local time, taken from the mobile phone clock (not given from GPS).

Settings: middle section

It is a window that can vertically scroll and where the parameters in the table must be entered.

TIME AND PLACE	
<i>Manual coordinates</i> (latitude and longitude)	These are the coordinates that are used when the GPS is not able to fix the satellites and determine the position. They can be entered via the map or by typing the values. To force the use of manual coordinates, it is necessary to move the GPS/ Manual switch towards this last position
<i>Coordinates style</i>	It allows you to choose between the representation of angles in degrees, minutes, seconds or degrees and fractions of degrees. Regardless of this choice, the values entered in input must always be entered in degrees and fractions of a degree
<i>GPS-Manual switch</i>	It is used to communicate to the algorithm which coordinates to use, whether those detected by the GPS or those entered manually above.
MEASUREMENT METHOD	
<i>Method</i>	By pressing this button you can select the method for measuring the direction of the sun's rays (see Orientation function)
FIXED	The measurement will be done by hand, by pointing the smartphon towards the Sun
GNOMON	The user must frame the shadow of a vertical pole projected on a horizontal plane
SHADOW	The user must frame the shadow of the edge of a building projected on a horizontal plane
SLIT	The user will have to place a small device capable of forming a line of light under the camera
<i>Accuracy</i>	You can choose among 3 levels. This parameter defines the sharpness requirement of the scene framed by the camera. The greater accuracy corresponds to the need to have a clean image in which the shadow or line of light is perfectly recognizable
<i>Sun direction</i>	It should be used for all methods except FIXED. It is a parameter used by the algorithm in measuring the direction of view of the Sun. If during the measurement the Sun is in front of the mobile phone, UP must be selected, if it is behind it, DOWN must be selected
<i>Calibration parameter</i>	In this box you must indicate the parameter, in degrees, which takes into account any misalignments of the camera of the mobile

	phone. This value is subtracted from the slope of the line of light or shadow
<i>Use accelerometer</i>	Select YES if, using the SLIT method, the mobile phone cannot be used perfectly aligned horizontally. The accelerometer data is taken into account in the calculation of the North direction. For other methods, the use of the accelerometer is only recommended to check the horizontality of the smartphone
<i>Accelerometer calibration</i>	Press here to enter the accelerometer calibration
<i>WEATHER</i>	
<i>Temperature</i>	Enter the temperature, in Celsius degrees, of the place where the measurement is made. The value is used for the calculation of refraction and is particularly important at sunrise and sunset
<i>Pressure</i>	Enter the pressure, in atmospheres, of the place where the measurement is made. Pressure is also used for the refraction calculation
OTHER GRAPICH SETTINGS	
<i>Memo GPS</i>	Select ON if you want the program to warn you when the GPS is turned off
<i>Compass animation</i>	Select YES if you want to see smooth compass movement. Selecting NO, the compass moves sharply
SEND ANONIMOUS DATA	
<i>Send measurement data</i>	Select YES if you agree to send anonymous data when a measurement is done by using SLIT, GNOMON or SHADOW method. Data are collected in a server and used only for scientific purposes. Data sent are date/hour, latitude/longitude, method/accuracy, measured azimuth/magnetic azimuth (if a magnetometer is available) and software release.


Settings: lower section

In this section there is a "RESET" button that allows you to restore all the parameters to their default value and a "COMPASS" button to start the compass functional pages.

EPHEMERIS PAGE



This page provides the following astronomical information

LTT	Local True Time. This is true solar time, when the Sun reaches its highest point at noon and exactly in the south direction (north, if you are in the southern hemisphere)
Date (GMT)	Greenwich Date
Time (GMT)	Greenwich Time
LOCAL TIME	Local time (given by internal clock)
Lat / Long	Latitude and Longitude
TVF	True time of the central meridian of the time zone
NMEA	NMEA string given by the GPS
ET	Equation of time, which is the difference between real time and mean time
TETA	Hourly rotation angle of the Sun (around the earth's axis) with respect to the local meridian
Decl.	Declination angle of the Sun, that is the angle between the plane of the celestial equator and the Sun
Refr. angle	Refraction angle of light caused by the atmosphere in the direction of the Sun
Elev.	Elevation angle of the Sun above the horizon
Azimuth	Direction of view of the Sun with respect to the geographical directions South and North
GMT diff	Time difference with respect to GMT due to time zone and daylight saving time (to set in sunrise/sunset calculation page)
Sunrise	Time and azimuth of the Sun at the instant of the dawn
Sunrise viewpoint slope	Inclination between the sight direction of the Sun at dawn and the horizontal plane, set by the user
Sunset	Time and azimuth of the Sun at the instant of the sunset
Sunset viewpoint slope	Angle between the direction of view of the setting Sun and the horizontal plane, set by the user
Sun transit	It is the local time (on the clock) in which the Sun passes exactly on the meridian, so it indicates the true noon of the place
From J.C. Birth	Total number of days elapsed from 1 January of year 1
Week-day	Sunday, Monday...
Julian-day	Number of days elapsed since Greenwich Mean Day January 1 of the year 4713 BC.


NOTE: the ephemeris data refer to the date / time given by the GPS (or by the phone) but the user can set any other date / time using the icon  (a series of buttons opens with which the data is entered) and by switching the lower "Date Type" selector to the left position. It is also possible to change the coordinates, in order to calculate the ephemeris at another point on the Earth. Coordinates are entered as for the date and time, while the selector to be moved is indicated by the caption "Coord. type". ATTENTION: when setting the time manually, remember that this time refers to that of Greenwich. The program does not take into account any local time zone or summer time set by hand, as it does so automatically via the longitude of the place.

Sunrise and Sunset calculation

The calculation of Sunrise and Sunset is performed by coordinates, date and time provided by the GPS but it is possible to manually set these values (see previous note). In particular, it is also possible to calculate the time of sunrise or sunset according to the elevation of the sun (in the event that it rises or

sets, for example, behind a mountain) and also you can choose the time of the event depending on whether the Sun is just tangent to the horizon (above or below) or cut in half. To do this, when you press the icon , select "Sunrise Sunset" to enter the angle of the elevation that the Sun will have at sunrise or sunset and the relative position of the Sun with respect to the horizontal line behind which it rises. or set. The time of sunrise and sunset is calculated with respect to Greenwich time therefore, in order to be reported to local time, it is necessary to set the time zone and the presence of daylight saving time referring to the place whose outcome you want to know of the calculation. The time zone and daylight saving time setting is done by pressing the icon  and selecting the item "Set time zone".

Date and time of the Sun transit

The app is able to calculate the day of the year and the time in which the Sun transits for a pair of values, set by the user, of elevation and azimuth. To do this, when you press the icon , select "Calculate date" and, in the window that opens, set the required azimuth (with respect to the South direction, positive towards West), the elevation in degrees, even negative, and the year for which the calculation is requested. Coordinates other than those of the place where you are located and the value of the time zone can also be set. Once this is done, press "Go search" and, after a few seconds, the system will calculate the two dates of the year in which the Sun transits at the minimum distance from the set coordinate point. The time relating to this calculation is the local time of the place with the chosen coordinates, taking into account the time zone but not daylight saving time. In addition to the date and time, a deviation is indicated, that is the error due to the fact that the Sun may never pass exactly through those coordinates. The data is acceptable (i.e. there is actually a day / hour combination for which the Sun passes through the selected point) if the error is a few hundredths.

Accelerometer calibration

Since the result of the compass measurement is strongly influenced by the horizontality of the mobile phone when the camera image is acquired, it is important that the accelerometer is correctly calibrated. The app allows you to perform a self-calibration procedure by pressing the "CALIBRATE ACCELEROMETER" button located on the settings page. Once you have entered the calibration page there are two ways to proceed. The first requires that a surface is available whose perfect horizontality is known. In this case, place the mobile phone on this surface, wait a few seconds to check that the numbers given by the inclinometer stabilize and then press "OK". If you do not have a horizontal surface, you can proceed as follows: place the mobile phone on the surface by putting it along a given direction (for example the edge of a book), wait for the numbers given by the accelerometer to stabilize and press the "+90" button. Then, rotate the mobile phone 180 °, aligning it exactly along the previous direction, wait for the inclinometer to stabilize and press the "-90" button.

Important note: if the phone's camera lens sticks out of the back, position the mobile phone so that it only touches the flat region.

PARKING function: see the "Orientation" section under "FIXED Method"