Naked Eye App Documentation

A documentation and manual for the „Naked Eye"-mobile application for Android-devices

Contents:

I. What it is all about

1. Why we need you

This App is part of a scientific survey. The data, uploaded by the users will be filtered for nonsensical information and then statistically analyzed, therefore directly supporting our study.

Generally, there are two ways to answer certain questions concerning naked eye astronomy:

1. You can build physical models of the atmosphere, the stars, the human eye, and so on.
2. You can conduct a empiric study and analyze your own observations.

While the first possibility is sufficient in many cases, physical models are always only an approximation of reality. An empirical study might therefore deliver differing results whenever the models are highly simplified. The problem for this second possibility is, that

most of the time you need quite a large number of single observations, ideally from many different people, more ideally under many different circumstances.
This is why we need all of you! Please help us to gather as much data as possible, please also propagate the App to your interested friends and colleagues.

2. The initial question

The project behind this App was started in summer of 2018 at the faculty of physics and astronomy (Physikalisch-Astronomische Fakultät, PAF) in Jena. The problem we focused on was to determine the exact date of a heliacal rising for an arbitrary star. This date denotes the first day in the year on which the star can be seen rising during dawn, only to vanish shortly after due to the brightening sunlight.

Heliacal risings are of huge importance to several ancient cultures as they are more or less fixed to the seasons. On the contrary, if the respective culture used a calender without leap years, the seasons (and also the heliacal rising dates) will move between the years (with roughly ¼ day per year).

So whenever an Egyptian scholar mentions on which date of the current year Sirius had its helical rising, we can fix this year of their historical calender to the respective year in ours. This exact procedure has in fact been used by many historians but it can hold a vast error, depending on the question when exactly a star can be seen during twilight.

3. Some theory behind the study

As mentioned above, our initial goal was to answer the question on which night of a year a star can first be seen during dawn.

This is not a new question and we are not the first ones to try and answer it (in the end of this paragraph there is some suggested literature for anyone willing to dig deeper into the topic).

What distinguishes our study from previous works is mostly our approach. While questions like these are usually answered by more or less extensive physical models, we chose to start an empirical survey among amateur astronomers.

Nevertheless here is some of the theoretic basics behind the question
When starting with the question of the heliacal rising of a single star, you can quickly generalize it to: **„Under what conditions can a star be seen by the human eye?"**
If our eyes can detect an object, mostly depends on:

→ how big the object is / how far away it is
→ how much light itself emits compared to how much light the surrounding emits

For stars, the first condition can always be assumed to be the same: They are so far away that we can only see them as point sources, never as two-dimensional objects.

So to fully answer the question we will either need an empirical study about the perception of such point sources in the eye or a solid optical model of the eye and its „light sensors", but for astronomers it is less interesting, as it will only give something like a constant factor that we have to include for every star.

The answer to the second question is more diverse, as each star has a different brightness and the background brightness of the sky is also varying vastly through each day.
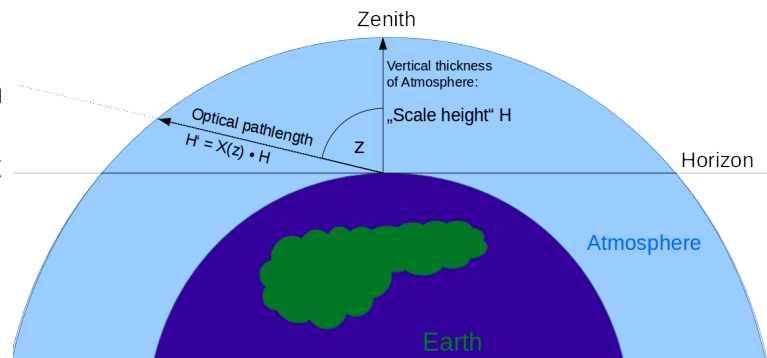
So we want to inspect further on which variables both brightnesses depend.

The brightnesses of the stars can be photometrically measured and for those visible to the naked eye, they are well documented and usually given as their **magnitude m** which is a logarithmic expression of their light flux outside the atmosphere. This magnitude again depends on the sensor and optical filter, the star was measured with and may even be varying in time due to different physical reasons. Luckily, all the optical condition are

standardized and the variability is also well documented so **m** (plus in the case of variable stars, **Δm** at the time of observation **t**) is a variable we can work with.
Of course, m is only constant for a viewer outside the earths atmosphere and can be heavily dependent on current atmospheric conditions. In astronomy these influences are summarized as „atmospheric extinction" **E**, a term referring to the dispersion and absorption of light by gas molecules.

Briefly said, of the original light flux from outside the atmosphere, only a certain percentage gets through to an observer on earth.
This percentage mostly depends on the thickness of the atmosphere above from sea level **H** (and altitude of the observer above sea level **a**) but also on the zenith-angle **z** under which it is seen (see Figure).

Lastly it also depends on the current thermodynamic state of the atmosphere which can be approximately described by temperature **T**, pressure **p** and humidity **AH**.
So expressed as a formula, we now have:

Star brightness   **b* = b* (m, Δm(t), E)**   and   **E = E (H'(z), a, T(t), p(t), AH(t))**
                                                                                    and   z = z (t, λ, β) → time and star position

These are quite a lot of variables but all of them can either be easily measured (t, a, T, p, AH) or looked up for a known star (m, Δm, λ, β)

So now let us look at the sky's brightness b^{SKY}. The reason, our sky is bright during the day is mostly that the sunlight is scattered in all directions when traveling through the atmosphere and therefore we can also perceive light coming from every direction in the sky.
Therefore the sky's brightness at a certain star position z*, Az* (Az being the Azimuth angle) depends mostly on the current position of the sun and also the moon but additionally on the atmospheric state.

Therefore we get: $\mathbf{b^{SKY} = b^{SKY} (z^*, Az^*, z^{SUN}, Az^{SUN}, z^{MOON}, Az^{MOON}, T, p, AH)}$

Again, all the positions can be looked up and the atmospheric values should be relatively easy to measure.

That means...
...in theory it should be possible to give an answer to the initial question based on all those variables if we just include enough data in our analysis.
Our app offers the possibility to collect such data. Obviously, we have to allow for quite large errors in measurement, as this is anything but a controlled laboratory-experiment.
But we hope that we can statistically minimize those errors by (again) the sheer mass of data.
If many people around the world participate, we are confident that our goal can be reached.

4. Possible extensions

The first version of the App will be / was launched in spring of 2019. In this version the only function is to click on stars you can see at the moment and then upload these lists to our on line database.

Although this is a relatively basic (and for some also easy) task for the observer, it can already help us a great deal because the conditions of the observation are automatically recorded and sent along the list of stars, giving us many variables on which the simple question may depend.

However, this is not the only possibility in which a large number of observers can help by simple naked-eye-observations.

We hope that the App will establish itself as a tool which can be modified to answer many different research questions in the future.

Such questions might concern the perceived color and brightness of stars, as well as their exact rising or setting times. It might also be used for recording transient sky phenomena like aurorae, meteorites or halo displays.

So be prepared for more features to be discovered in the future...

II. Screen by Screen explained

1. The start screen

1.1 Purpose:

The start screen is meant to give you a short overview about your Position and weather data. It also tells you when exactly the upcoming twilight will be, as for our purpose, this is the most interesting time to observe.

You can also enter the help-screen as well as the actual observing (star-selection-) screen from here and if more features are added to the App in the future, you will be able to choose between them from the start screen.

1.2 Design:

After getting a GPS-Signal and internet connection

Elements (from top to bottom):

- The GPS- and Network-Icon
  Shows if you currently have a GPS-Signal / Internet connection

- The Help-Menu
  Opens the help/contact/about-screen

- The Exit-Button
  Closes the App. Be sure to save/upload your data first!

- Warning No GPS-Signal...

  This warning is shown if you haven't received geographical coordinates in the ongoing session

- What do you see? - Button Select Stars

  Press this button to get to the Star selection screen. If you don't have geogr. Coordinates or don't have any info entered, a warning will be shown and you will not get to the Star selection screen.
  If you're missing the info and also don't have any available you can observe anyway by pressing „Enter info manually" and then „continue w/o info".

- Get info from web – Button

  Apart from the geogr. Coordinates, all info shown on the screen is not mandatory for the observing task. If you have an internet connection available, it should automatically be filled in, as soon as you have gotten a GPS-signal.
  Nevertheless it can happen that old or incomplete information is shown. In this case you can try to **reload the information by pressing this button.**
  ATTENTION: If you have entered your own info values, pressing this button will erase them (when Internet connection is provided) even if you unchecked the „Update info automatically"-check-box

- Enter info manually – Button

  If you don't have internet connection but do know some of the required information (Temperature, atmospheric pressure, air humidity and height above sea level) from other sources, you can enter them manually. **Pressing this button will open a drop down menu** with several new features.

- Drop-down menu for entering information
  This is only shown after pressing the Enter-info-manually-Button!

There are 4 text boxes where you can **enter numeric values** for the info parameters. The **expected unit** is given in the respective background text. To the left of each text box there is a check-box.
If each check-box is checked, the info values will be automatically updated whenever an internet connection is available.
However it is well possible that your own measurements of the info values are more precise then the values from the internet.

In this case, please uncheck the regarding boxes and your own values will remain.
Below the text boxes, there are two buttons. **Pressing the „Enter info" - Button** will save all the entered info-values.
By **pressing the „Continue w/o info" - Button** you can enter the star-selection-screen even without any info (except geogr. Coordinates which are mandatory!)

- **Information display**
  The current info is shown in two columns.

  Left column: Position
  - Lon: geographical Longitude in degrees
  - Lat: geographical Latitude in degrees
  - City name and Country code (if available)
  - Height above sea level in meters

  Right column: Weather
  - Outside Temperature in degrees Celsius
  - Atmospheric pressure in hecto pascal (reduced to sea level!)
  - Atmospheric humidity in percent

- **Timezone – Button**
  Displays current Timezone and allows you to **enter Timezone manually** if the App got it wrong


- **Twilight times display**
  Gives information on when the upcoming twilights will take place. The upper line is for dusk, the lower one for dawn. **The green circle-arrow** has to be pressed once to display the times and again if you want to update them (e.g. if you moved your position significantly)
  Twilights denote time spans between the given points in time where the sun is at specific horizontal heights.
  The exact classification is as follows:
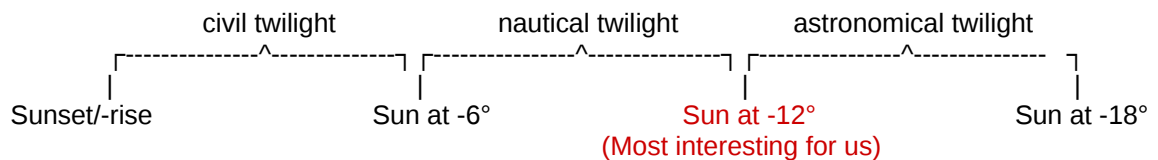
  Although the point between nautical and astronomical twilight is most interesting for our study, you can also observe some time earlier or later. Our goal is to make use of any data, you share with us.


2. The star selection screen

2.1 Purpose:
The star selection screen is something like the main screen of the app. Here you can **select** and **deselect** stars and **add** the selection to your preliminary list. This list can then either be **saved** to the devices memory or directly **uploaded** into our on line database.
You can still see and update the current weather and position info but you can not manually alter the values as you could in the start screen. Values which were set to not be automatically updated in the start screen will neither be automatically updated here, only if you hit the update-button.
You can also enter the help-screen from here, as well as go back to the start screen.

2.2 Design:
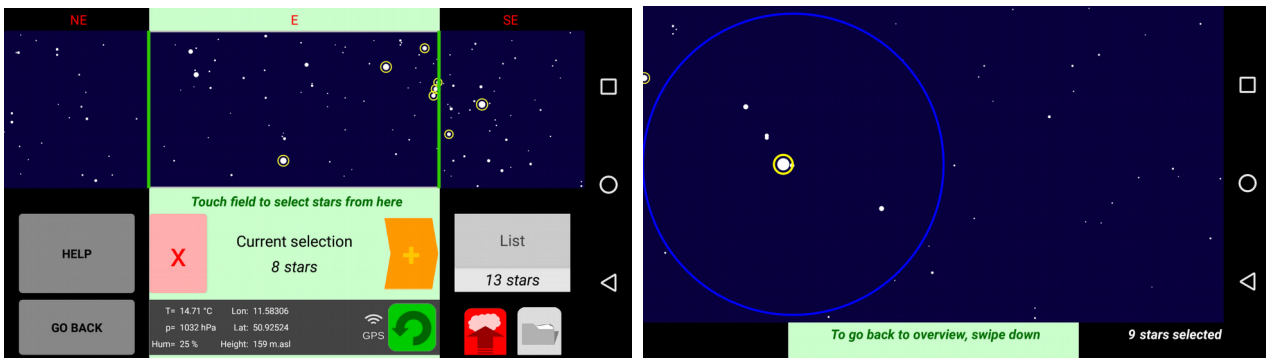
Standard design with all interactive elements (Overview-mode)

Selection mode with opened lens

Elements (from top to bottom):

- <u>Display of cardinal directions</u>

Shows in which line of sight the app is displaying stars. **You can turn to the next direction by simply swiping across the sky-display**. In selection mode, only the centered direction can be seen and only this one is displayed (when lens is closed)

- <u>Sky-Display</u>
In overview mode: The sky-display shows the part of the sky, corresponding to 30° of height above your local horizon and 110° of azimuth around the middle cardinal direction. The green lines delimit the area which can be seen in selection mode. Within this part of the sky you can see all stars up to the 5th magnitude where the sizes of the dots correspond to the magnitude. You can **switch into selection mode by touching the middle part of the display** or swiping up

  In selection mode: The sky-display shows the part of the sky, corresponding to 30° of height above your local horizon and 55° of azimuth around the middle cardinal direction. **You can turn to the next direction by simply swiping across the sky-display.** Note that there is minimal overlap between the directions so most of the stars can only be seen when looking in exactly one of them.
  Touch a star to select or deselect it! If you touch an area with multiple stars nearby, a lens will open showing all the stars close to your touch in 6x magnification. **Touch the sky outside the lens to close it** or just select stars within the lens as usual.
  Swipe down to return to overview-mode

- <u>Instructions</u>

Tells you how to switch between modes. In selection mode, it will additionally show the number of selected stars

The next components are arranged in three groups next to each other (left and right with black background, middle one with green)

Left Group:

- Help-Button to enter the help-screen

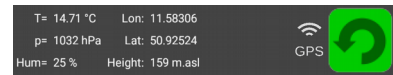- Go-Back-Button to return to start screen

HELP

GO BACK

Middle Group:

- Clear-button to clear the current selection

X

- Selection display with number of currently selected stars

- Add-button to add the current selection to the list

+

- Info display
Shows current weather- and position-info as well as an
GPS- and a Internet-Icon to show if you currently have either signal.
Press the green circle-arrow to update the info and the stars position in the sky display. This will overwrite info which was set to not be *automatically* updated in the start screen.

T= 14.71 °C	Lon: 11.58306	
p= 1032 hPa	Lat: 50.92524	
Hum= 25 %	Height: 159 m.asl	GPS

Right Group:

List

13 stars

- List-button and -display:
Pressing the button will open the current list (explanation below).
Beneath the button, the number of stars in the current list is shown.

- Upload-button:
Pressing the button will upload the current list to our on line database.
A window will open first to confirm. If no internet connection is available, you will be asked to save the data to you device.

- File-menu-button:
Pressing the button will open the file menu where you can either save the current list to your device or open a saved list. When saving the list, you can enter a file name. The default name will be the current time and date. **When pressing „Open" you will also have the possibility to delete files!**

When the list-button was pressed, a display of the current list will open:

The top line shows you the 9 values given for each star. These are:

- **HipNr:** As Identifier the number of the star within the Hipparcos Catalogue

- **Az, Height:** The horizontal coordinates of the star when it was selected

- **Mag':** The value of the stars radius in pixels. This is calculated from its magnitude.

- **Lon/Lat:** Your geographical position when the star was selected.

- **Alt_asl:** Your height above sea level when the star was selected.

- **UnixTime:** Time when the star was selected in milliseconds since 1970

- **T, p, Hum:** The weather values when the star was selected

If you want to delete a certain star from the list, your best chance will be to look up its Hipparcos-Number and identify it this way.
In list view you can:

- **Delete single entries** by selecting them in the list and confirming in the pop-up-window.

- **Delete the whole list** by pressing „CLEAR"

- **Return** to overview-mode by pressing „HIDE"

2.3 Handling your star selection:

The following diagram shows how exactly the buttons on your interface manipulate a star selection:
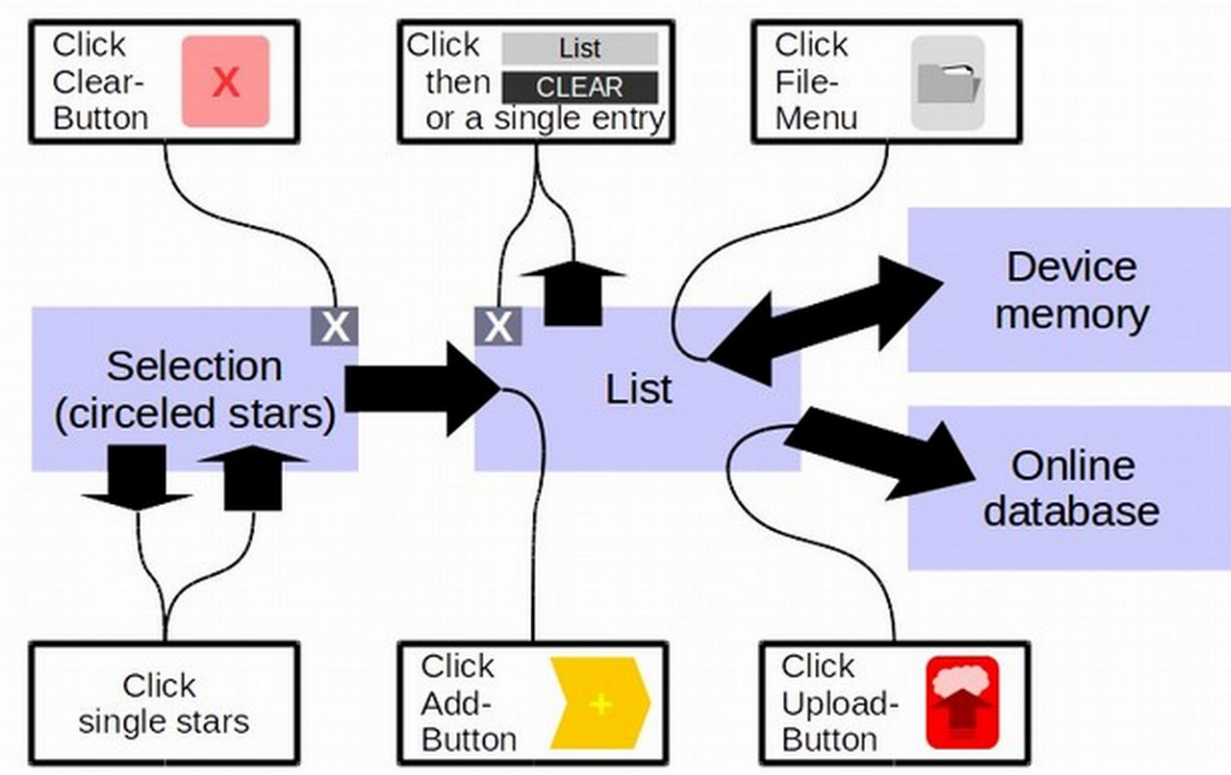
3. The Help Screen

The help screen can be accessed either by pressing the ?-button in the start screen or pressing the HELP-button in the star selection screen.
It has 4 tabs which can be chosen between by pressing on them in the top line. Pressing BACK brings you back to the screen you came from.
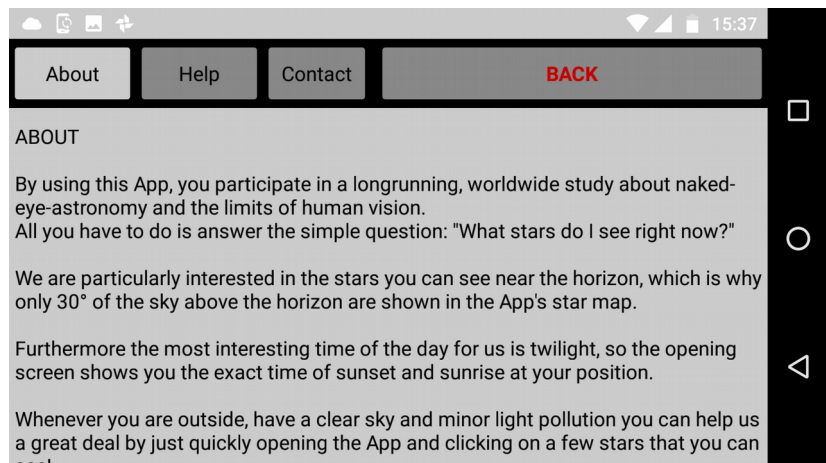
III.   Prerequisites and guidelines for using

1. Prerequisites

Although the basic question of seeing or not seeing a certain star can be answered by almost anyone, it is still necessary to identify the star you can see.
We tried to make the identification as simple as possible, showing the sky above your momentary horizon. Basically the only thing left to do is to recognize the same patterns of stars in the App and in the night sky. What makes it more difficult however is that during twilight only the brightest stars can be easily seen. Therefore the patterns in the sky might look quite different compared to the ones in the App where all stars (up to the 5th magnitude) are visible.
Nevertheless, with some observing experience, you will quickly be able to find the most prominent stars. You will also be able to see more stars as you learn where to look exactly.

To summarize, everyone can help us but the more stars you can safely identify the more valuable your data is.
Despite that, please be careful to...

NEVER UPLOAD A STAR THAT YOU CAN **NOT** SAFELY IDENTIFY!

The whole project relies on the participants to be true to their actual observations and not make up sightings that did not happen.

IT IS **NOT** A COMPETITION IN WHO CAN SEE THE MOST STARS

2. Guidelines

First things first, the most important guideline is, as mentioned above:
NEVER UPLOAD A STAR THAT YOU CAN **NOT** SAFELY IDENTIFY!

Best practice when selecting stars:

- Try to observe only under **good conditions**
  That means: no precipitation, no clouds, no light pollution

- Try to observe **during twilight** (especially end of nautical / beginning of astronomical or the other way around in the morning) and preferably select stars **close to the horizon**

- Try to select **dark stars** that are hardly visible **rather than brighter ones.** These are more significant for our study. But always **make sure you really see the star.**

- **Regularly add your selection to the list.** The list is meant as a temporary storage. Advantages of adding stars and not keeping them all in the selection are:
  - you can not accidentally delete them by pressing the clear-button
  - the app runs faster
  - the weather values are saved when adding the stars not when selecting them so

adding regularly will deliver more precise values for each star

- Try to **confirm your selection before adding** it to the list. Even though there is a possibility to delete single false entries from the list and even clear the whole list, you should only be doing that if you know how to identify entries witin the list. (See description in II.2.2). It is easier if you don't have to manipulate the list at all.

- Only save lists if you don't have internet connection at the moment. Delete lists once you have uploaded them.

- **ONCE YOU UPLOADED YOUR LIST YOU CAN NO LONGER ACCESS OR MANIPULATE IT!**

Beyond that, here are a few tips that might help you (and us if you follow them)…

- This App is not the best App out there for displaying the sky. In particular, it only shows the first 30° above the horizon and navigation within the sky-field is somewhat limited. Other Apps can therefore easily help you to identify stars better.

- Especially during twilight you sometimes have to stare intensely into one spot (or next to it) in the sky for some time before you can see the star. This is because on the one hand your eye has to adapt to the darkness and on the other hand the stars are sparkling due to atmospheric extension, sometimes making them visible only for short time spans.

- You can upload stars multiple times during one session. This will be especially helpful in the morning as stars gradually vanish and it is most interesting when you last saw them.

- Try to get different stars under different circumstances. It is less helpful for us to have 1000 sightings of Vega in the middle of a mild summer night than to have 10 sightings of stars between the 2. and 4. magnitude during twilight in 4 different seasons.

- If you have weather or altitude data of your current position available through direct measurement, this will most likely be more accurate then the data, the App automatically gets from the Internet. In this case, please enter the data manually and uncheck the respective check box for automatic update.

IV. Contact, Acknowledgements and Legal Information

The App „Naked Eye" is distributed under:

**Creative Commons
CC BY-NC-ND 3.0 license
(February 2019)**

You can **Download** the App or get there by scanning the QR-code:

The App was developed, using the on line tool MIT App Inventor 2

Contact:

If you have any problems, suggestions, comments, ideas, criticism, praises or questions, please contact us under:

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Acknowledgements:

The App was developed, using the on line tool MIT App Inventor 2

We want to thank the following API providers for the free info, displayed in our App:

- *www.openweathermaps.org* for the weather values, city name and country code
- *www.geonames.org* for the geographic height and timezone
- *www.sunrise-sunset.org* for the twilight times

Furthermore we want to thank Vitaly Gorbachev from Flaticon who designed the sunrise- and sunset-icon used in the start-screen.

Privacy policy:

To use our App you will have to permit access to your location data and your devices memory ("media files").

The memory is only used to save and read lists of stars that you couldn't upload right away.

The location data is crucial to us, as it defines your local horizon and the exact position of the stars and sun at the time of observation.
With uploading your star list, you agree to share your location data with us but we do NOT need or save any other personal data that could help to identify you.

Additionally, your position data will be part of requests, sent to the API providers (see "Acknowledgements"). This is necessary to get your current weather data, etc...
By using this App, you also accept these provider's privacy policies.

We hereby guarantee that we analyse the location data, that you shared with us, anonymously and will only use it for scientific purposes.
Except for your position, we do not read any personal data from your phone.
Our database is therefore completely anonymous.

Your location data will never be shared with any third parties but the API-providers mentioned in the "Acknowledgements".