MBNA Publishing House Constanta 2021

Proceedings of the International Scientific Conference SEA-CONF

SEA-CONF PAPER • OPEN ACCESS

The Development of a C# GUI Astronomical Navigation Calculator

To cite this article: E. G. ROBE-VOINEA, P. BURLACU and M. G. ICHIM, Proceedings of the International Scientific Conference SEA-CONF 2021, pg.319-322.

Available online at www.anmb.ro

ISSN: 2457-144X; ISSN-L: 2457-144X

doi: 10.21279/2457-144X-21-041
SEA-CONF© 2021. This work is licensed under the CC BY-NC-SA 4.0 License

The development of a C# GUI astronomical navigation calculator

E G Robe-Voinea, P Burlacu and M G Ichim

"Mircea cel Batran" Naval Academy, 1 Fulgerului Street, Constanta, Romania

Abstract. The project contains a calculator which determines the specific values of astronomical navigation. Firstly, the algorithm of the program determines the meridian angle and the declination of any Star based on daily page table and correction table. Then, with specific formulas, the program calculates the altitude of any Star and Azimuth angle. The C# language was used for the code along with Graphical User Interface. The project also contains a theoretical part explaining the variables of the equations used in this program.

1. Introduction

This article is about developing an astronomical navigation calculator which accurately determines values which help for orientation on the sea. The project has two sections: theory and calculator. In theory section there are information about the variables that are used for the calculator and in the second section there is the calculator itself. For the first part of the calculator there are navigation tables which can be found in a specific almanac, precisely correction table and declination of any star table. The code behind the project is written in C# and it was used a Graphical User Interface for the program design.

Students usually use the form from figure 1 in order to learn to calculate the specific values of Astronomical Navigation and the program is based on this form.

Date	__/__/____	Lat. = ° ′	Long. = ° ′
Chronometer time	C = h m s		d sign: +if Dec. increasing - if Dec. decreasing
Chronometer error	+ CE = □ m s		
Universal Time	UT = h m s		
Finding the meridian angle and the declination of the Sun			d =□ ′
Daily pages →	UT = h	GHA = ° ′	Dec. = ° ′
Inc. & Corr.pages →	UT = m s	+ Inc. GHA= ° ′	+Corr. Dec. =□ ′
±360° if required		GHA = ° ′	Dec.= ° ′
+for Eastern Long. / - for Western Long.		+ Long.=□ ° ′	
±360° if required		LHA = ° ′	if LHA<180°; t_W=LHA if LHA>180°; t_E=360°-LHA
Meridian angle		t □= ° ′	
Finding the calculated altitude (H_C) and the azimuth (Az)			
Lat. = ° ′	Dec.= ° ′	t □= ° ′	
$\sin(H_C)$=	if Lat. and Dec. same names	$\sin(Hc) = \sin(Lat.)\cdot\sin(Dec.)+\cos(Lat.)\cdot\cos(Dec.)\cdot\cos(t)$	
	if Lat. and Dec. diff. names	$\sin(Hc) = -\sin(Lat.)\cdot\sin(Dec.)+\cos(Lat.)\cdot\cos(Dec.)\cdot\cos(t)$	
$H_C=\sin^{-1}$(value) = ° ′			
ctg(Zs) =	if Lat. and Dec. same names	$ctg(Zs) = \frac{tg(Dec.)\cdot\cos(Lat.)}{\sin(t)} - \frac{\sin(Lat.)}{tg(t)}$	
	if Lat. and Dec. diff. names	$ctg(Zs) = -\frac{tg(Dec.)\cdot\cos(Lat.)}{\sin(t)} - \frac{\sin(Lat.)}{tg(t)}$	
$tg(Zs) = \frac{1}{ctg(Zs)}$ =	$Z'_S = tg^{-1}$(value) = ° ′	if ctg Z_S > 0, Zs = Z'_S	Z_S= °.
		if ctg Z_S < 0, Z_S=Z'_S+180°	Z_S= °.
		Finding the azimuth using Norie's tables	
Zs = $\frac{N}{S}$ °. $\frac{E}{W}$	$\frac{N}{S}$ – same as Lat.	Lat. = ° ′	A = $\frac{N}{S}$
		Dec.= ° ′	& B = $\frac{N}{S}$ (Norie's rules)
			C = $\frac{N}{S}$
	$\frac{E}{W}$ - same as t□	t □= ° ′	Zs = $\frac{N}{S}$ °. $\frac{E}{W}$; Az = °.
Az = °.	if Z_S = Nα°E then Az = α° if Z_S = Nα°W then Az = 360°-α°	if Z_S = Sα°E then Az = 180° - α° if Z_S = Sα°W then Az = 180° + α°	

Figure 1. Altitude and Azimuth calculation guidance

2. Program Interface

The program contains panels, text boxes, picture boxes and buttons. The panels were used as pages and their visibility is false at the start, but when a specific button is hit, they will be visible. The radio buttons become available when the "Theory" button is pressed.

The first panel, shown in figure 2, contains an information which helps the user navigate in the program.

The second panel (figure 3) is shown by pressing the "Theory" button and contains general information about the variables used for the calculator.

The third panel (figure 4) is shown by pressing the "Altitude of a Star" button and contains the definition of the declination of a star and the formula that was used for the calculator in order to generate its value.

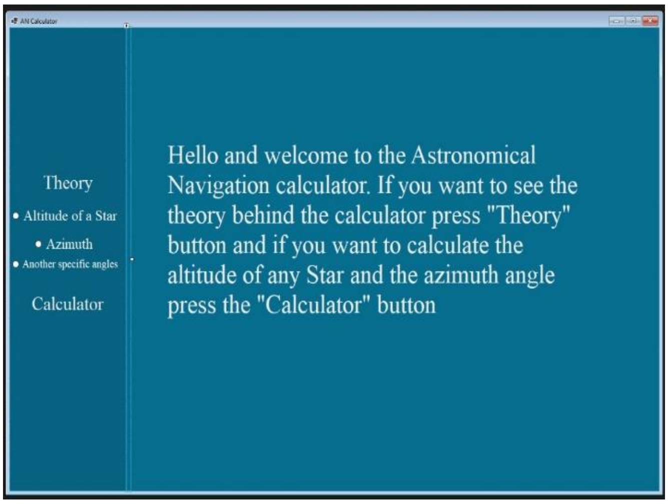

Figure 2. First panel was designed as an introduction to the program.

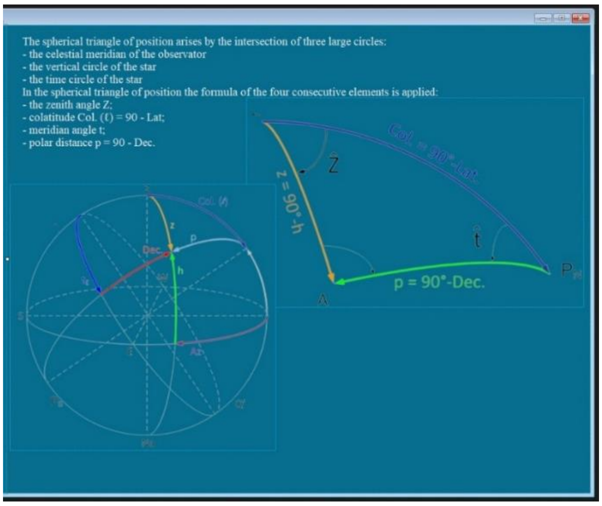

Figure 3. The initial theory panel introduces the nomenclature to the user.

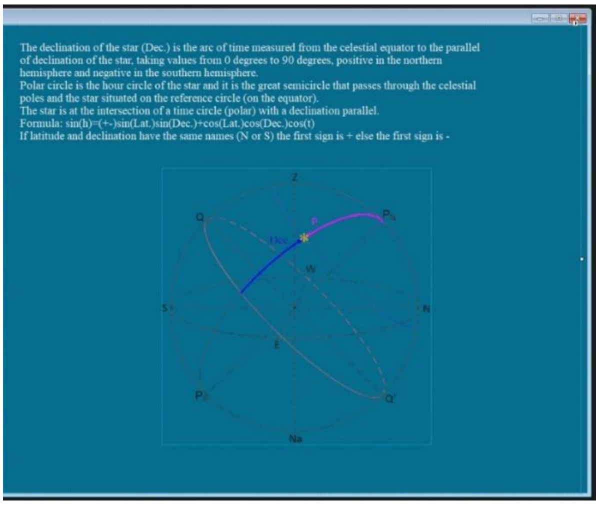

Figure 4. Definition of the declination and altitude of a star equation

The fourth panel (figure 5) is shown by pressing the "Azimuth" radio button and contains the definition of azimuth angle and the formula behind the calculator. The fifth panel (figure 6) is shown by pressing "Another specific angles" and contains theory about local hour angle, sideral angle, based on the rotation of the earth beneath the stars [1], and meridian angle which was used for the calculator's code.

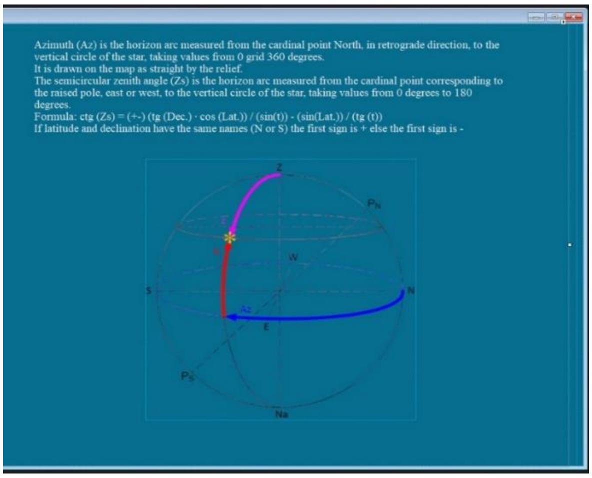

Figure 5. Azimuth definition and its equation

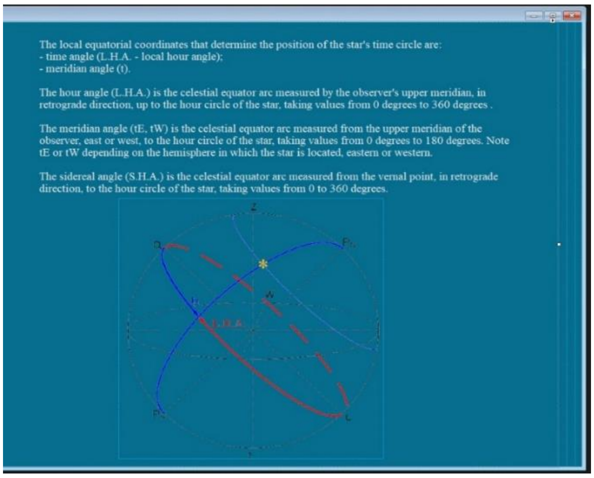

Figure 6. The local hour angle, sideral angle and meridian angle definition

The last panel (figure 7) is shown by pressing "Calculator" button and contains the astronomical navigation calculator which uses the tables of calculated altitudes and azimuths, along with the method of plotting position lines [2]. The input values have borders along the text box and the output values have not. In order to input values, the two specific tables are needed: correction table and declination of the star table. The calculator uses the equations mentioned in figure 4 and figure 5. The Azimuth and Altitude values will be visible when the "Calculate" button is pressed.

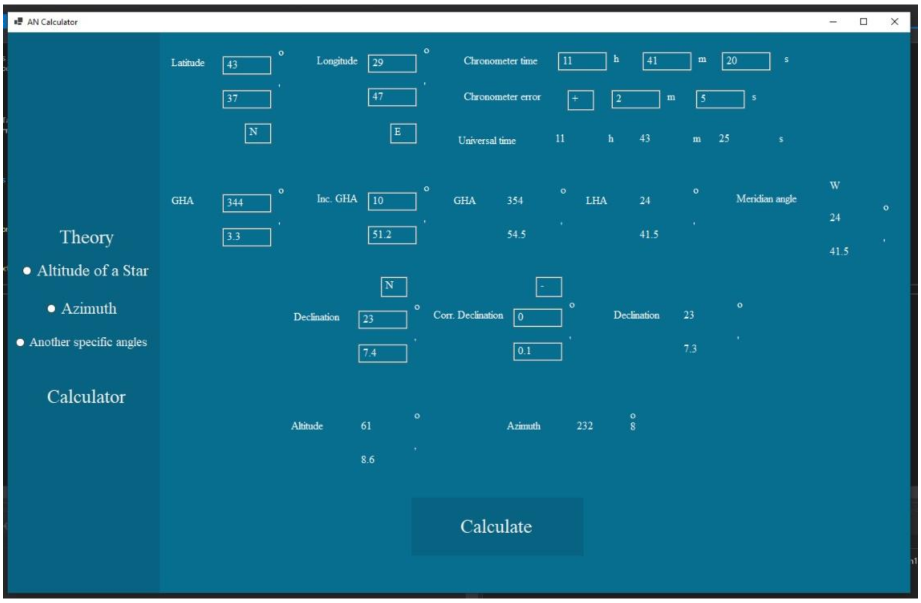

Figure 7. Calculator Interface

Compared to the handwriting method, shown in figure 8, the program only needs the input values. Its main advantage is the reduced time needed by the user to reach the results. By using the computer, there is no error in the calculations.

Date	30/06/2020	Lat. = 43°37′ N	Long. = 29°47′ E
Chronometer time	C = $11^h 41^m 20^s$		d sign: +if Dec. increasing - if Dec. decreasing
Chronometer error	+ CE = $2^m 5^s$		
Universal Time	UT = $11^h 43^m 25^s$		
Finding the meridian angle and the declination of the Sun			d = □ '
Daily pages →	UT = 11^h	GHA = 344°03′.3	Dec. = N 23°07′.4
Inc. & Corr.pages →	UT = $43^m 25^s$	+ Inc. GHA= 10°51′.2	+Corr. Dec. =-0′.1
±360° if required		GHA = 354°54′.5	Dec.= 23°7′.3
+for Eastern Long. / - for Western Long.		+ Long.= 29°47′ E	
±360° if required		LHA = 24°41′.5	if LHA<180°; t_W=LHA if LHA>180°; t_E=360°-LHA
Meridian angle		t W= 24°41′.5	

Finding the calculated altitude (H_C) and the azimuth (Az)		
Lat. = 43°37′ N	Dec.= 23°7′.3	t W= 24°41′.5
$\sin(H_C)$= 0.87583	if Lat. and Dec. same names	$\sin(Hc) = \sin(Lat.) \cdot \sin(Dec.) + \cos(Lat.) \cdot \cos(Dec.) \cdot \cos(t)$
	if Lat. and Dec. diff. names	$\sin(Hc) = -\sin(Lat.) \cdot \sin(Dec.) + \cos(Lat.) \cdot \cos(Dec.) \cdot \cos(t)$
$H_C=\sin^{-1}(value)$ = 61°8′.6		
ctg(Zs) =-0.76037	if Lat. and Dec. same names	$ctg(Zs) = \frac{tg(Dec.) \cdot \cos(Lat.)}{\sin(t)} - \frac{\sin(Lat.)}{tg(t)}$
	if Lat. and Dec. diff. names	$ctg(Zs) = -\frac{tg(Dec.) \cdot \cos(Lat.)}{\sin(t)} - \frac{\sin(Lat.)}{tg(t)}$

$tg(Zs) = \frac{1}{ctg(Zs)}$ = -1.31515	$Z'_S = tg^{-1}(value)$ = -52°45′.1	if ctg Z_S > 0, $Z_S = Z'_S$	Z_S=
		if ctg Z_S < 0, $Z_S = Z'_S + 180°$	Z_S= 127°.2

Zs = $\frac{N}{S}$ 127°.2 $\frac{E}{W}$		**Finding the azimuth using Norie's tables**		
	$\frac{N}{S}$ – same as Lat.	Lat. = ° ′	A = $\frac{N}{S}$	Norie's rules
		Dec.= ° ′	& B = $\frac{N}{S}$	
	$\frac{E}{W}$ - same as t□	t □= ° ′	C = $\frac{N}{S}$	
			Zs = $\frac{N}{S}$ °. $\frac{E}{W}$	Az = ° .
Az = 232 ° .8	if Z_S = Nα°E then Az = α° if Z_S = Nα°W then Az = 360°-α°		if Z_S = Sα°E then Az = 180° - α° if Z_S = Sα°W then Az = 180° + α°	

Figure 8. Sample of calculations [3]

3. Conclusion

The program works without internet and it can be used from any computer. It can also be used by students in class to learn to make these calculations. An easy and friendly user interface can save time and can help studying astronomical navigation. For the future, more equations can be implemented, a wider theory can be added, and the image of the program can be improved. A smartphone version can be created as well.

References

[1] Glass I S 2012 *Nicolas-Louis de la Caille, astronomer and geodesist* Oxford (University Press).

[2] Sadler D H 2010 Sight Reduction - Sextant Observations for the Seafarer. Graeme Richards, 172 pages, 3 plates and 68 figures, paper-covered boards, 8·7 × 5·6 in., Nautical Publishing Company (Lymington, Hampshire) 1969, 32s. Journal of Navigation. Cambridge University Press; 23(1):128–9.

[3] Astronomical navigation course notes, "Mircea cel Batran" Naval Academy.