MBNA Publishing House Constanta 2021

Proceedings of the International Scientific Conference SEA-CONF

SEA-CONF PAPER • OPEN ACCESS

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To cite this article: Elena-Grațiela ROBE-VOINEA, Ovidiu CRISTEA, Ion CHIORCEA and Paul BURLACU, Proceedings of the International Scientific Conference SEA-CONF 2021, pg.71-76.

Available online at www.anmb.ro

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

doi: 10.21279/2457-144X-21-009
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Matlab GUI for real wind components with NMEA sentence information as input data

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Abstract. From sailing vessels to motor vessels and, maybe in the near future, autonomous vessels, all have in common one very important aspect: how to harvest or tackle the wind. Thus, it is very important for navigation students to understand the wind components and how naval equipment transfer information from wind station to bridge information system using NMEA protocol. The article presents a method of extracting information from NMEA 0183 standard phrase and calculate the Real wind components (direction and speed). For a better understanding of wind vectors calculus, we propose a GUI created in Matlab, which is also use for displaying NMEA phrases and extracted information like: Heading, Speed Over Ground, Relative(apparent) wind direction, Relative (apparent) wind speed. Also, the algorithm can be used for further research in autonomous vessels domain.

Key words: Matlab GUI, wind components, NMEA, autonomous vessels, didactic

1. Introduction

The idea of building a graphical interface to solve the problem of calculating the components of real wind (Real wind direction and Real wind speed) in the composition of the ship's wind and apparent wind, has its beginnings in 2017, during the training march with N.S. Mircea, during which time, due to the malfunction of the wind sensor, it was solved with the help of the cadets' countless values of the real wind. Moreover, the following year he settled aboard the N.S. Mircea a weather station produced by a Romanian company that, at the first software variant, had errors in determining and graphically displaying the real wind. Although at first glance it may seem a simple problem, its implementation involves some challenges given that the application is at the intersection between sailing and mathematics.

Knowledge of the components of the real wind is very important in the naval field, both for sailing ships and ships with modern propellers. Therefore, the second motivation for creating this interface was to create teaching software that students could use to visualize the apparent wind in the composition of the real wind with the ship's wind.

Following the bibliographic study, we identified articles from which we were inspired to create the GUI interface in Matlab, as is the case with the VectGUI interface [1] created for students, which has the main purpose the graphical display of vector computational elements used in electromagnetis. Other examples used are [2] creation of a virtual laboratory for the study of inductive machines; [3] creating a GUI for electromagnetic field visualization and [4] developing a GUI in Matlab for detecting and locating faults in a transmission line. All these interfaces use the built-in functions in Matlab for vector calculation.

2. Real wind components briefing

The wind speed is measured onboard the ship with the anemometer and the direction with the help of the electric weather vane. It must be borne in mind that the direction measured onboard a ship stationed at the quay or anchor is identical to that of the actual wind. If the ship is moving, the direction in which the weather vane, the flag or even the smoke of the ship is heading is a relative direction and is called the apparent wind direction. The direction in which the weather vane is oriented is the result of the vectorial composition of the real wind and the ship's wind. The ship's wind is given by the movement of air masses as a result of its advance and can be represented by a vector equal and opposite to the speed of the ship.

If we note with:

$\overrightarrow{Vr}$ – real wind vector;
$\overrightarrow{Vn}$ – ship' wind vector;
$\overrightarrow{Va}$ – apparent wind vector,

We can write the relationship:

$$\overrightarrow{Va} = \overrightarrow{Vr} + \overrightarrow{Vn} \quad (2.1)$$

or

$$\overrightarrow{Vr} = \overrightarrow{Va} - \overrightarrow{Vn} \quad (2.2)$$

It should be mentioned that the wind enters the compass, which means that the direction from where the wind blows is specified, and the sea current comes out of the compass, which means that the direction where the current goes is specified.

To graphically represent the solution of the problem we take an example: Da = 45 ° with a speed of 12 Nd (6m / s); wind from the direction of 270 ° with a speed of 15 m / s. The composition of the vectors shows the direction and speed of the real wind according to figure (2.1)

Suppose a ship is moving in a general road D with the speed Vrot which is the speed given by the rotations of the propeller. The real wind blows from a sector bow with a given force and makes with the axis of the ship an angle denoted q

As a result of the action of the wind on the hull, a force (F) is produced whose point of application is the hull center of the ship and which has a certain direction and size. Decomposing this force F after two systems of perpendicular axes we obtain two components Fx and Fy - Figure (2.2).

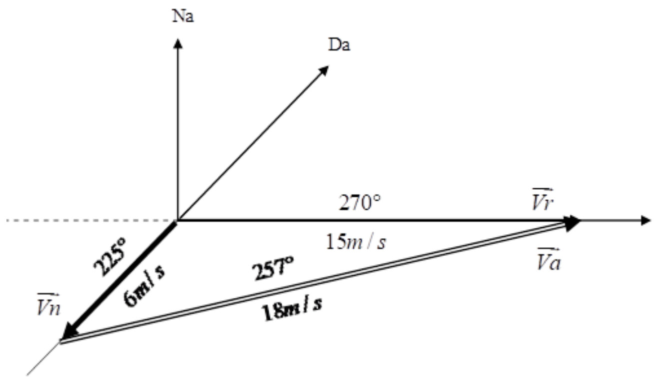

Fig. 2.1 – Wind's components detmined by vector calculus

The composition of Fy with Vrot determines as a result of Vf what is the ships's speed over the ground and which has as direction Df - the ship's way above the bottom. We notice that between D and Df the angle "α" was formed, which represents the wind drift. The force Fx results in braking the ship, so with the drift, there is a reduction in travel speed.

Wind drift is influenced by the following factors:

1. the ratio between the surface of the dead work and the surface of the living work - large dead work determines a large drift;

2. wind force - double-action due to the production of waves. Directly proportional effect;

3. wind direction concerning the longitudinal axis of the ship - minimum of bow and stern with action on speed, maximum with crosswind;

4. ship speed - inversely proportional to drift. Stopped cars mean maximum drift;

5. the ship's embankment. The ship's embankment is the successive and irregular deviation of the ship's axis on either side of the direction of travel as a result of the action of the waves and the placing of the rudder on the opposite side to return to the direction of travel. It is asymmetrical with the direction of travel and can cause the drive to increase or decrease [5].

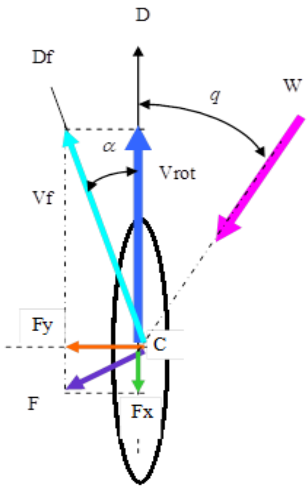

Fig. 2.2 - Composition of forces drifting in the wind.

3. NMEA protocol & Matlab GUI

A software product development includes several preliminary steps such as analysis, design, writing, testing, debugging, and maintenance. Although they are considered separate stages, there is a strong relationship of interdependence, the ultimate goal being to obtain an efficient software solution that can evolve.

3.1 Matlab implementation

Unlike [5] where the interface was designed to allow visualization of the classical (graphical) solution of problems dealing with wind estimation by entering data manually, "soft_v2_NMEA" comes with the possibility of entering input data from NMEA protocol sentences. Thus, the interface allows the user to enter parameters such as Ship's direction, Ship's speed, Apparent wind direction, Apparent wind speed using NMEA sentences: HEDT, GPVT, MWW (Fig. 3.1)

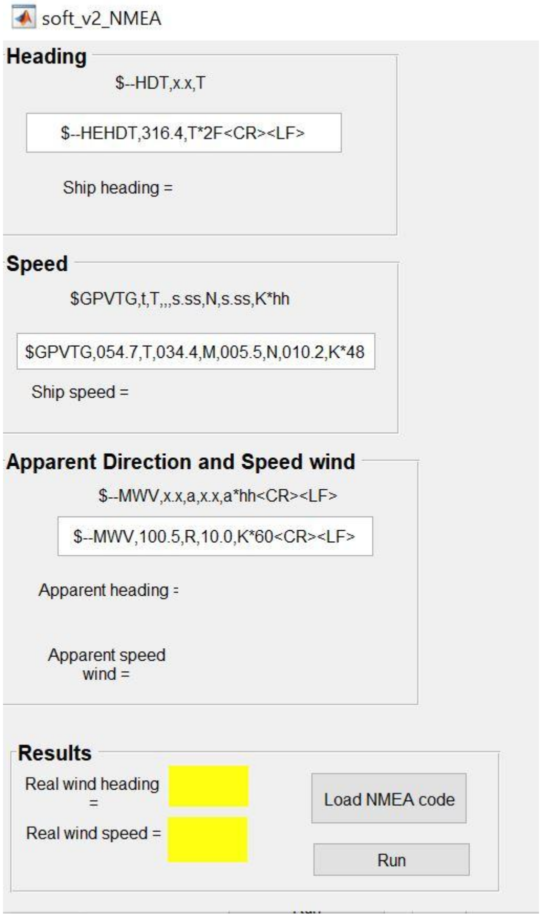

Fig.3.1 – Input data section

After executing a query, the program provides results such as Real wind heading and speed. These are displayed according to the figure above in the fields marked in yellow. The graphical interpretation of the obtained results is made in vector form in order to display the graphical composition of the vectors for a better understanding of the wind graph estimate (Fig. 3.2).

The image below shows an example in which the ship's heading (270°) coincides with the inverse of the ship's wind being represented by the colour red. Blue is represented by the apparent wind vector (335°). The result of the two, and the result of the final calculation is the green vector representing the real wind (032.5°). It can be observed that from a mathematical point of view the subtraction of the two vector components according to relation (2.2) was performed using the triangle rule (fig. 3.2). It can also be seen that the actual wind composed of the ship's wind by the parallelogram rule results in the apparent wind vector.

All the vectors of the wind components have the point of application in the origin and the direction towards the outside of the board, precisely to respect the rule according to which the wind enters the compass. For example, in the case of the true wind of 32.5°, it is displayed starting from the origin towards its opposite angle of 212.5°. Also, this vector is parallel with the resulting vector which connects the edges of the Ship's wind vector (red) with the relative wind vector (blue). In this way is graphical represented the subtraction of vectors as is in equation (2.2).

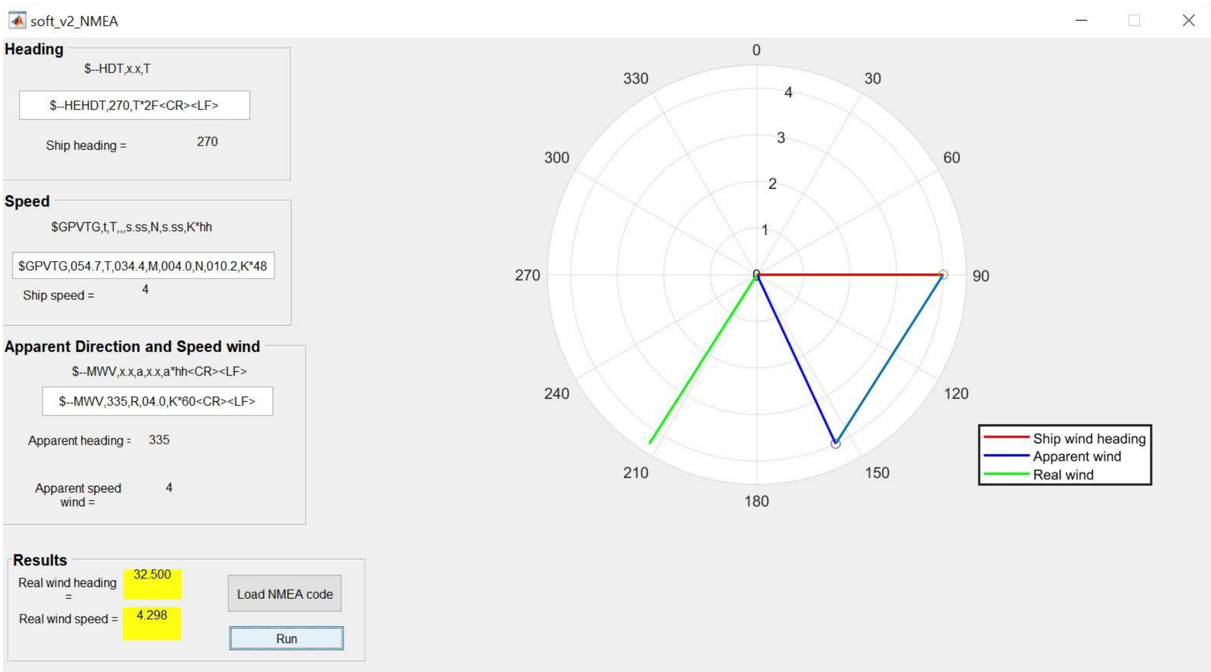

Fig. 3.2 Graphical representation of wind's vector components

4. Conclusions

The graphical interface for calculating and displaying the components of the real wind and its components using vector functions in Matlab can be used both for teaching purposes and as an integrated part of a real navigation system onboard a ship. Following the tests performed, the source code followed the proposed mathematical calculation algorithm, without generating more. We can distribute the source code to those who want to develop similar applications.
In the future, we intend to implement new functions so that the algorithm runs in parallel with a data acquisition system to which a wind sensor (gyro-anemometer) is connected. Also, from a didactic point of view, the application can be developed for use in radar navigation and radio-electronic navigation as well as naval kinematics.

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