Correspondence of the paths of the Sun and Moon as the basis for building a model calendar and database of extreme natural phenomena

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**Abstract.** This scientific work aims to construct a mathematical correspondence of the Sun and Moon paths on the cartesian coordinates of a flat plane to design a database of 100% Moonlight brightness (Full Moon) and 0% (Dead Moon). The moment of the Full Moon and the Dead Moon is a potential time for a lunar and solar eclipse, thus it is said that the sun, earth and moon are in a line position. The proposed mathematical approach is to use linear functions. Mathematical approach The proposed path of the sun y = x and the proposed mathematical approach to the path of the moon y = 1.03226 x - 643.The correspondence data of the sun's trajectory and the moment of the full moon and the dead moon are arranged in tabular form as information for early alert to possible extreme natural phenomena that can be raised.

 Introduction

Modeling is a form of skills / expertise that can be used in various applied fields, for example construction design models, fashion models, calligraphy models, photo models, graphic models, growth models, heat flow models, reaction models and so on. Basically, these skills can produce, express or inform a picture of the form of a phenomenon that is being studied. Mathematical modeling is a field of science that produces information about a phenomenon in everyday life in a mathematical form; Therefore, the first step to building a mathematical model is to make observations or observations of this phenomenon. Field observations (laboratory or open-air) are carried out to obtain traces of information about a phenomenon. Information from these observations is called observational data. Observation data is the main element for building a model, an image of the shape or model can be obtained / viewed after going through the process of plotting / mapping the observed data on Cartesian coordinates in certain dimensions according to needs (two-dimensional / in the plane, three-dimensional / in space). In general, models built from observational data are grouped into two types, namely probabilistic models and deterministic models. The probablistic model has the characteristic that the data obtained from the observation results are not periodic (fluctuation), while the deterministic model shows that the appearance of the observed data tends to be periodic. In this work, the observed data have a periodic tendency, thus leading to a deterministic model of a system, in this case the system of the Sun and Moon trajectories seen from the Earth's surface. The problem that will arise in the future related to the Earth's surface is the geographic shape of the Earth which is round so that one place can see the Moon / Sun for the region that is being traversed while other areas have to wait some time to get a turn. Next is what is necessary to look at the brightness of the Moonlight?

Earth with a surface in the form of land and oceans is where we humans live and the flora, fauna, climate and other conditions that accompany it. The islands that stretch apart from the ocean make a variety of nations, cultures, customs, languages ​​and so on. Therefore, history records many commemorative activities or traditional / cultural ceremonies carried out by people all over the world, in big cities and villages to celebrate these ceremonies from time to time and generation to generation. Technological developments and the progress of the times do not rule out a shift in the habit of celebrating commemorations or ceremonies, perhaps even being abandoned before they are studied and their potential is known. In general, the type of memorial or ceremony that continues to survive and is passed on from generation to generation is a sacred or spiritual type of ceremony. The sacred / spiritual ceremonial or commemoration activity is carried out at a certain time of day, month, duration of activity and legal requirements. Almost all spiritual ceremonies or religious holidays that occur are held at moments based on the Brightness of the Moonlight as the timing. Among other things: Islam (in determining Ramadan, Eid al-Fitr, and Eid al-Adha as well as other holidays); Buddha (determines Vesak when the Moon is 100% bright / full); Hindu (determines Nyepi when the Moon dies, 0%); Christian / Catholic (specifying Easter is the Sunday after the full moon in early spring); Konghuchu (determining Chinese New Year is after the Moon dies in the rainy season January / February).

The development of science and technology provides hope for solutions to problems that have occurred in everyday life and to anticipate recurrence of problems in the future. This effort is expected to help solve the problem with the foundation of the field of science as a foundation, in the end the effort is for common problems, especially those related to the natural phenomenon of the correspondence of the Sun and Moon trajectories. The basic mathematics used to model the trajectory of the Moon is a legacy of scientist Ibn Shina as stated in Angle Measurement, which is measuring the angle of the Moon against the horizon using a protractor, Al Jabar builds equations so that the correspondence between the Sun-Moon becomes simple, and scientific developments bring convenience. so that the trajectory phenomenon can be expressed in the coordinates of the Cartesian plane. The trigonometric function (Sine) is used as a function of the brightness of the Moonlight as well as to monitor where the Moon is. The design of the protractor is easy to design without reducing the expected output when compared to modern and expensive equipment. In the long term, mathematical modeling of Moonlight brightness provides hope in determining 1% brightness (Light crescent), 50% brightness (Light half moon), 80% brightness (Light humpback), 100% bright (Full Moon), 0 % (Moon is dead) and other percentages of brightness which have sacred / spiritual value to commemorate; For example, in the people of Mecca monitoring the brightness of the Moonlight 80% in the month of Dzulhijjah which is the 9th path is a spiritual ceremony to perform Wukup, that the Moon is on the 9th trajectory in the region 3, 4,5,6,7), and is known widely as Eid al-Adha.

**2. Materials and Methods**

*2.1. Observation Tools and Materials*

The tools and materials needed to make observations or observations of correspondence on the trajectories of the Sun and the Moon include: stop-watch, semicircular protractor, markers, balls and handles.

*2.2 Research Methods*

This material is used to detect the phenomena of the trajectory of the sun and the trajectory of the moon, as for the following steps that must be taken regarding the data required to build a database for the calendarization of the full moon and the dead moon moments are:

1. Mapping the surface of the Earth on the coordinates of the Cartesian plane (the result is an atlas map)
2. The duration and plots of the Sun and Moon trajectories on the coordinates of the Cartesian plane from sunrise to sunset
3. The difference in time duration or the gap between the sun and the moon from sunrise to sunset
4. The duration required when the Sun and Moon are together in the position of one projection line until the period is together with the next projection line (one qomariyah month)
5. Moon brightness (illumination) and the Moon's angle to the Sun (MES, moon-earth-sunset) data
6. Developing the main data into other data (angle / duration of lag, age of crescent or hilal)

The tools and materials described above are used to obtain data on the degree of the Moon's angle to the Sun (recommended measurements at sunset). Data collection of Moon brightness can be done by taking a photo of the Moon's brightness (camera) or by calculating it after the mathematical model is obtained. Further data analysis At the stage of data analysis, a log list is used or can use a calculator that has a sine function and / or use a computer with Excel software. Data analysis carried out in this study is to calculate the shift in the angle of the Moon to the Sun every day and the Moon's brightness is associated with the magnitude of this angle.

3. Results and Discussion

The agreement of previous scientists with regard to the mapping of the Earth on the coordinates of the Cartesian plane is the agreement that one day has a duration of 24 hours, then the globe (globe) is partitioned into 24 parts, in other words the Earth has 24 time zones and if mapped to the coordinates of the Cartesian plane will have the size of the coordinates of 24 intervals of abscissa / X axis and 12 intervals of ordinate / Y axis (figure 1). Consistently each partition (= 1 hour) is equal to 15 degrees so that one degree = four minutes. The next consequence is that the archipelago region from Sabang (-48 minutes to wib) to Merauke (+132 minutes to wib) has an interval along the X axis = 45 degrees equivalent to 180 minutes (3 hours) so that the archipelago is divided into 3 regions of wib, wita and wit 1 time, 2,3). If the path of the Sun and Moon is mapped to the coordinates of the Cartesian plane, the ordinate value (sb. Y) has shifted from time to time, periodically shifting from the gbu (22.5 degrees equinox), towards the center / X axis (0 degrees equator) , towards gbs (return south line -22.5 degrees), back again to the center / X axis and towards gbu and so on as a system of trajectory. The projection of the sun's trajectory from gbu-center-gbs-center-gbu is taken for 365.25 days (1 AD year), to facilitate daily life it is agreed that 1 year = 365 days and every four year period there is an additional 1 day due to the accumulation of 0.25 days / year (the addition is placed in February, which is usually 28 days to 29 days / leap year). Meanwhile, the projection of the Moon's trajectory from gbu-center-gbs-center-gbu is taken for 28 days.

The duration required for the Sun and Moon to coincide with a projection line until the period coincides with the next projection line is 29.5c days (c ≈ 2). The correspondence of the Sun and Moon trajectories is illustrated as Surya and Wulan racing around a circular field as shown in Figure 1.



The race starts at the stake at 18. Wulan is later than Surya, so when Surya finishes his first stage, Wulan is left behind on the dot-1 mark. And so on, every stage of Wulan lags consistently, so that on the 28th stage Wulan is seen in front of Surya and finally Wulan is caught up by Surya on the 29.52th stage (mark at 8: 10). From the illustration, one stage is the time of the sun's path from setting in the west at 18-midnight-rising / eastern-midday and setting back is 24 hours (one day). According to Almanac, the duration of 29.52 days is used as the length of the day in one hijri calendar month, therefore one hijri calendar year is 29.52 x 12 = 354.24 days. The brightness of the Moonlight can be seen for 28 days (1% - 100%), the 29th day of the Moon off (0%). Brightness of the 1st crescent moon (1st pass) 1- 3.5%, 7th trajectory of 50-60% brightness, 14-15th trajectory of 100% brightness, 21st trajectory of 60-50% brightness and trajectory of- 28 3.5–1% brightness and the 29th trajectory is a dead moon with 0% brightness. This research focuses on the extreme moments when the moon's brightness is 100% as the full moon or nisfhu and the extreme moments when the moon's brightness is 0% as the dead moon. There were facts that occurred when the Aceh-stunami occurred on the night of Sunday 14 Dhu'l Qaidah (full moon) 26-12-2004 and the tsunami-banten on the night of the week of Nisfhu jumadil-Akhir (full moon), 22-12-2018. The following extreme moments are presented in the form of a calendar of the moments of the full moon and the moments of the dead moon.







If the calendar is continued towards the future years, the calendar will satisfy y = x for the sun's path and y = 1.03226 x - 643 for the lunar path. Mathematically the two equations of the line will intersect at x = 19,932 (in the sense of M = H = 19,932).

4. Conclution

The extreme moments of the full moon and the dead moon need to be examined early in relation to the gravitational pull caused. There are other calendar systems in order to adapt to qomariyah-based extreme moments. Further research is suggested at the moment of the full moon and the dead moon in the super extreme phenomenon.

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