Navigating by the Stars

A BRIEF INTRODUCTION TO NAVIGATION BY CHRIS SARA

Foreword

Astronomy and navigation have the celestial objects in common; astronomy studies them, and navigation uses them to find your position on the Earth.

People have been utilising the stars for as long as they have been venturing about the surface of the planet. Even though the stars will move over time, we can treat them as fixed over the period of time we will be needing to use them for reference.

The earliest days of using the stars were as primitive reference points. Direction of travel was a basic way of using them. People would be mostly moving across land and many other markers were available to determine your position. As people started to travel further, and more importantly, across vast distances of water, more precise measurement was required.

People started to chart the stars. Their positions at given times was more closely noted and a greater understanding of their relationship to Earth formed the knowledge navigators would employ for many years to come.

Today we live in a technologically advanced society that as devices to show us where are, and even where we have been, so we don’t have the same reliance on the stars. However, technology can fail, but the stars will continue to shine (weather allowing) so knowing how to use them could possibly save your life.

Introduction

Until the innovation of Global Positioning Satellites (GPS) the stars were navigators' primary source of reference for moving about the planet. Over the centuries we have continued to develop better and better tools for navigating of course across the globe.

When the English mastered the keeping of time and charting of the stars, they were able to expand their empire and quickly spread across the globe, which to this day, remains the vastest empire in human history. The next great empire may be the one we forge across the Solar System, into the Galaxy, and ultimately beyond.

Here, I only touch on the basics of celestial navigation but hopefully it is enough to show you how the stars have been our guides for many millennia. Even with a little knowledge you can use the night skies as a way to indicate your location.

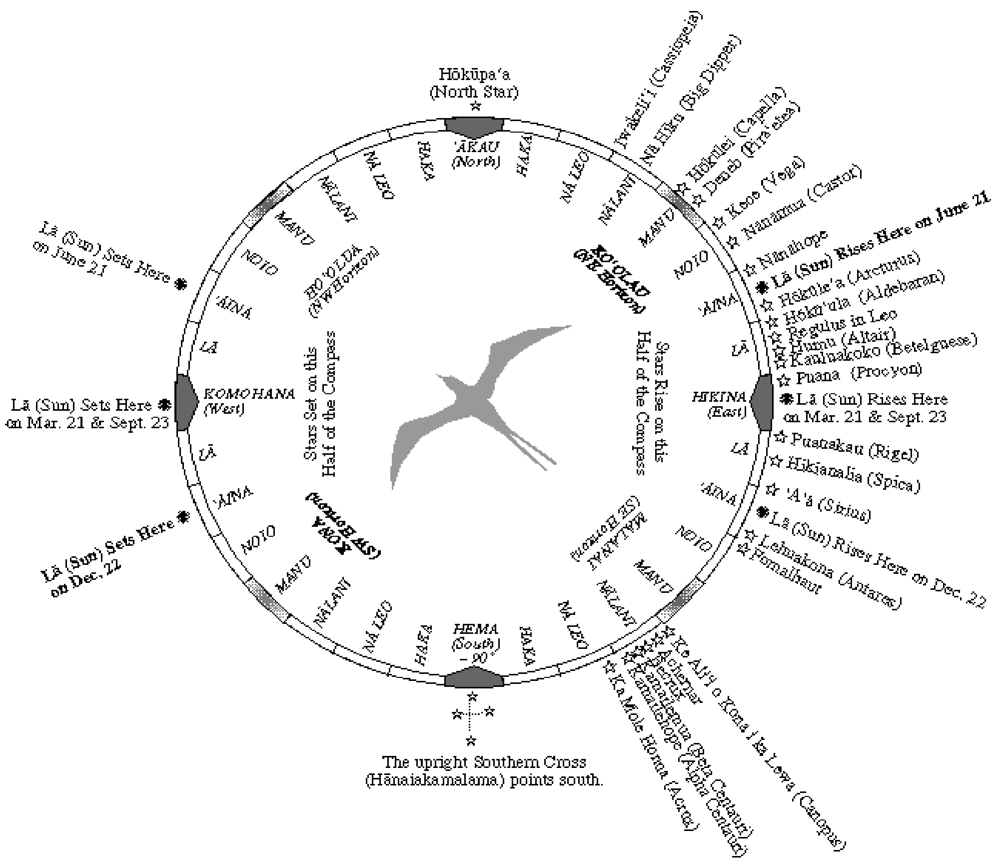
Navigation Techniques

Visual Navigation

When people first started to venture from their homelands, their eyes where their tools for navigation. They would observe the Sun, Moon, planets or stars and travel in the direction they knew them to represent. The Sun always rises in the east and sets in the west, so this is the most basic of astronomical references, and remember, it is the Earth that rotates and not the sky.

The position of "navigator" would become a crucial role for any society looking to expand their borders. Knowing precisely where you were and how to return meant your society could exist across vast expanses. Observations of the stars became more accurate and the knowledge began to be recorded. Where a written language did not exist stories about travelling using the stars would be relayed from generation to generation. The naming of stars and associated patterns (constellations) also developed.

The stars were, at this point, a major tool in the navigator's toolbox. The human eye and knowledge of nature served the earliest navigators well for many centuries. The people of the pacific are fine examples of a people who had a wonderful knowledge of the stars, and that knowledge allowed them to roam the pacific well before European explorers arrived.



An example of a Polynesian star chart

Mechanised Navigation

Advancements in science and engineering introduced technology into the world of navigation. Navigators were armed with telescopes, binoculars, clocks, compasses, sextants, star charts and maps of the world. These tools enabled precise movement around the world.

As a result of all the technologic advancements, trade and migration expanded across the world. People could have goods from all corners of the planet, and in turn, people could migrate to all corners of the planet. The world of today is still shaped by many of the consequences that resulted from this new found ability to navigate.

The Clock

When travelling across the land we generally have many visual clues, such as rivers and mountain ranges. A basic map and compass will be sufficient for most travellers, and in fact, it is still the basic form of navigation today. When we are at sea, or maybe in a desert, we have very few visual clues as the horizon is normally all we see. The one thing that is available are the stars laid out above us, so why not utilise them.

Since the Earth rotates and not the stars, they are effectivity fixed points in the sky relative to time. If we know what the time is, and we know where the stars should be at that time, then we can calculate our position on the Earth; granted, an overly simplified explanation of navigation using the stars.

This is where clocks come become important. A clock is our way of referencing time. European navigators travelled with clocks set to a standardised time from home. Star charts were generated relative to this standardised time and with the knowledge of time and star position in their procession, European navigators became the most travelled explorers of the time.

Positional navigation requires knowing your longitude and latitude. Latitude was simply calculated by measuring the altitude of a star off the horizon, which was done with a sextant, and looking up your latitude from the trusty tables. Longitude required comparing a stars' known altitude at time zero (home) and its altitude at the time you are making the measurement. The Earth rotates at a constant 15^o each hour (360^o ÷ 24hr = 15^o/hr) and this is the basis for calculating your longitude.

The "trusty" tables that I mentioned are the result of much calculation and without them sextants would not be that useful. There were some 57 named stars, covering many constellations, planets, Sun and Moon that were used for navigation. The following figure is an example of a table from a navigation almanac.

2011 January 19, 20, 21 (Wed, Thur, Fri)

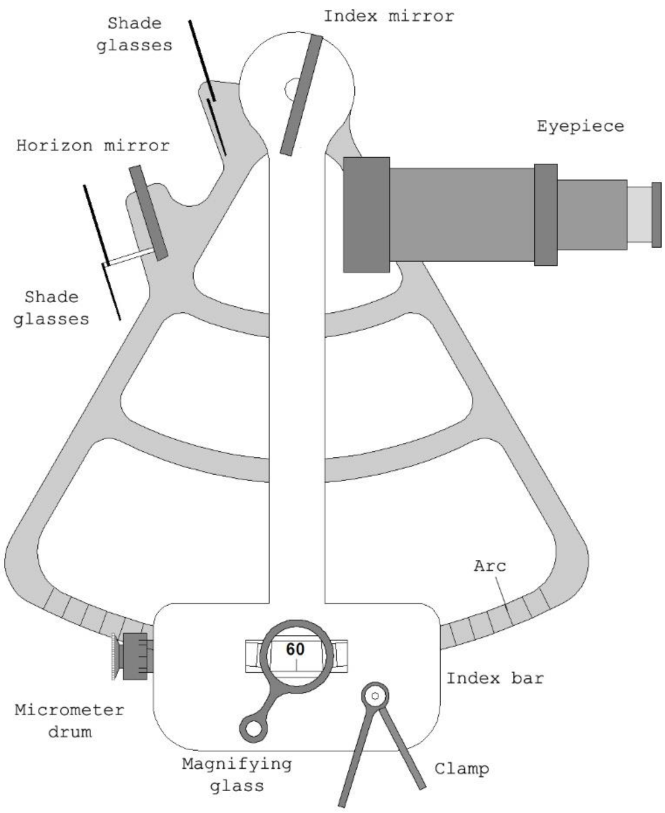
SATURN	+0.8	STARS			SUN		MOON				
GHA	Dec	Name	SHA	Dec	GHA	Dec	GHA	v	Dec	d	HP
281° 15'.2	4° 26'.6 S	Acamar	315° 19'.5	40° 15'.8 S	177° 22'.8	20° 27'.0 S	10° 09'.4	6'.1	21° 08'.5 N	7'.6	59'.3
296° 17'.6	26'.6	Achernar	335° 28'.0	57° 11'.1 S	192° 22'.6	26'.5	24° 34'.5	6'.0	00'.9	7'.7	59'.4
311° 20'.0	26'.6	Acrux	173° 11'.1	63° 09'.5 S	207° 22'.4	26'.0	38° 59'.5	6'.1	20° 53'.2 N	7'.8	
326° 22'.5	26'.6	Adhara	255° 13'.5	28° 59'.4 S	222° 22'.2	25'.5	53° 24'.6	6'.1	45'.4	8'.0	
341° 24'.9	26'.6	Aldebaran	290° 51'.1	16° 31'.9 N	237° 22'.0	25'.0	67° 49'.7	6'.2	37'.4	8'.1	59'.5
356° 27'.3	26'.6				252° 21'.8	24'.5	82° 14'.9	6'.1	29'.3	8'.3	
11° 29'.8	26'.6	Alioth	166° 21'.9	55° 53'.6 N	267° 21'.6	23'.9	96° 40'.0	6'.2	21'.0	8'.4	
26° 32'.2	26'.6	Alkaid	153° 00'.1	49° 15'.1 N	282° 21'.4	23'.4	111° 05'.2	6'.3	12'.6	8'.5	
41° 34'.6	26'.6	Alnair	27° 46'.2	46° 54'.5 S	297° 21'.3	22'.9	125° 30'.5	6'.3	04'.1	8'.7	59'.6
56° 37'.0	26'.6	Alnilam	275° 47'.8	1° 11'.8 S	312° 21'.1	22'.4	139° 55'.8	6'.3	19° 55'.4 N	8'.8	
71° 39'.5	26'.6	Alphard	217° 57'.5	8° 42'.6 S	327° 20'.9	21'.9	154° 21'.1	6'.3	46'.6	9'.0	
86° 41'.9	26'.6				342° 20'.7	21'.3	168° 46'.4	6'.4	37'.6	9'.1	
101° 44'.3	4° 26'.6 S	Alphecca	126° 12'.6	26° 40'.4 N	357° 20'.5	20° 20'.8 S	183° 11'.8	6'.4	19° 28'.5 N	9'.2	59'.7
116° 46'.8	26'.6	Alpheratz	357° 45'.5	29° 09'.3 N	12° 20'.3	20'.3	197° 37'.2	6'.5	19'.3	9'.4	
131° 49'.2	26'.6	Altair	62° 10'.2	8° 53'.9 N	27° 20'.1	19'.8	212° 02'.7	6'.5	09'.9	9'.4	
146° 51'.6	26'.6	Ankaa	353° 17'.5	42° 14'.9 S	42° 19'.9	19'.2	226° 28'.2	6'.5	00'.5	9'.7	
161° 54'.1	26'.6	Antares	112° 28'.6	26° 27'.3 S	57° 19'.7	18'.7	240° 53'.7	6'.6	18° 50'.8 N	9'.7	59'.8
176° 56'.5	26'.6				72° 19'.5	18'.2	255° 19'.3	6'.6	41'.1	9'.9	

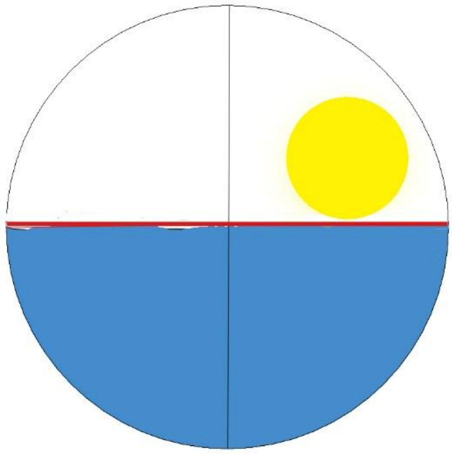
When using a sextant there are also a few corrections that need to made before your final measured angle is applied to the table. These relate to things like your height above the horizon (*aka Dip*) and refraction errors, caused by the light being bent when it passes through the Earth's atmosphere (tables for this are also available).

A good knowledge of the stars is also important. When you are attempting to spot given stars in an eyepiece, they very often all start looking the same. By using the filters (shade glasses on the sextant diagram following) some light can be blocked and the brighter stars will be left, and these are the ones most used in the tables.

The Sextant
As an astronomer with an engineering background, I think sextants are a beautiful thing. This device appears to be quite complicated but there is a simple principle that governs its use. In its simplest form it is a view finder and protractor, which are used to measure the differential angle of a specific object from the horizon.

In practise the use of a sextant for navigation is quite involved, but the principle of how it works is relatively straight forward. The basic idea is to align a target object with the horizon when viewed through the eyepiece. The insert image in the following diagram illustrates what you would observe if aligning the Sun with the horizon.





View through eyepiece

In this case, the user reflects the Sun via the index mirror, onto the horizon mirror (which is half silvered), aligning the Sun image with the horizon using the index bar. You then apply the clamp to lock the index bar in place. You can then read the angle of arc from the magnifying glass and micrometer drum. You would note the precise time of measurement and then consult your tables to determine your location.

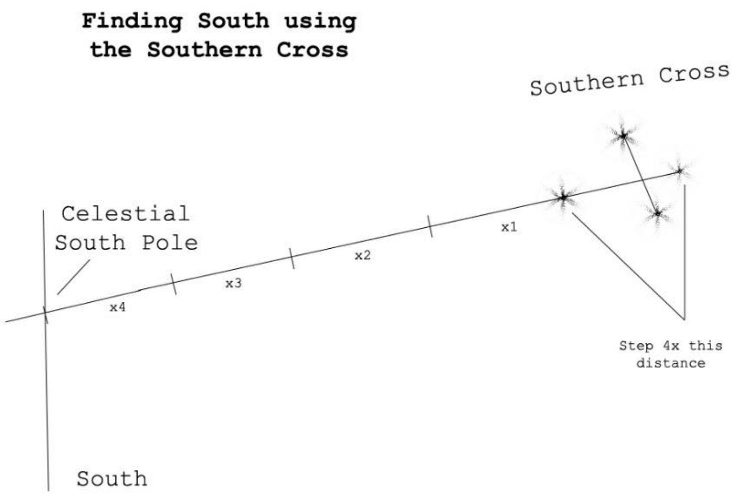
With their shade glasses, mirrors, vernier, locks and swing bar many sextants have a real gothic / steampunk look. The filters are for observing the Sun without damaging your eyes, or enhancing the stars, planets or moon. The micrometer and vernier allow for precise incremental angle measurement. You can resolve down to 10 seconds of arc. One degree of arc can be divided into 60 minutes (60'), and 1 minute can be divided into 60 secs (60"), so 10" is quite accurate.

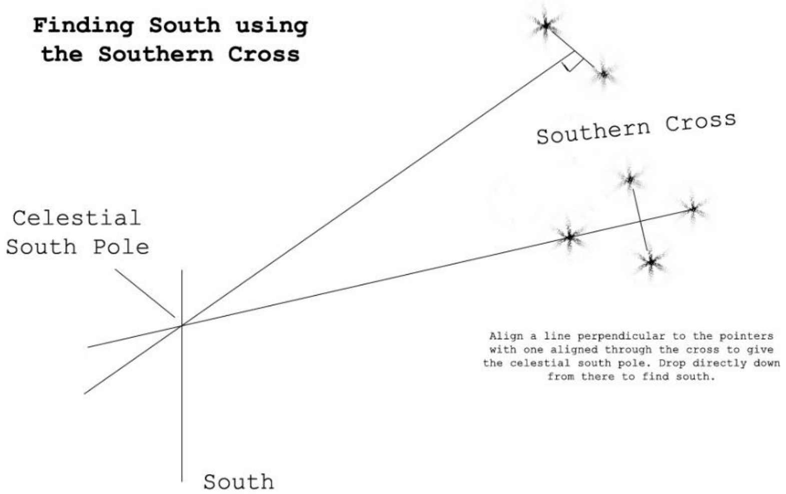
A good sextant and navigator can calculate their position within 1 nautical mile; however, 3-5 nautical miles is a more normal result. When you have travelled from the other side of the globe and arrive within that distant of your planned location it is pretty good.

Using the Southern Cross

The most relevant use of the stars in our everyday life in Aotearoa would be finding south and the south celestial pole using the Southern Cross, Crux.

Unlike in the Northern hemisphere there is no star that is bright about the celestial south pole. Polaris, or the pole star, is what the people in the north use to find the north pole, and we use the Southern Cross. The following figures illustrate a couple of ways we can use the stars of Crux to find south.





Summary

As with so many things in a world that is becoming more and more reliant on technology the art of navigation using the stars is another victim of progress. There is almost an irony in the fact that we now know more about the stars then ever, but our use of them in our everyday life is decreasing as fast as our knowledge of them is increasing.

When it comes to astrophotography the satellites that we rely on for navigation are actually an issue. More and more satellites are meaning that we are in danger of never getting images that don’t have an unwelcome satellite trail running through them

There is something romantic about moving around the globe armed with a star chart, clock and sextant. Sextants now have a value based on their collectability rather than their use, and in reality, are pretty hard to find. I will keep an eye out for one, and maybe I may look to make my own, even if it is a basic example of how they work.

As I continue to enjoy my observations of the stars, and although I have no practical use for navigational skills, knowing that it is a skill related to the stars draws me to the knowledge. I have so much to explore when it comes to astronomy and this little look at navigation hopefully sparks an interest in those reading this essay.