Analysis of Lakes over the period of time through Image Processing

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Abstract. The Great Salt Lake, located in the northern part of the U.S. state of Utah, is the *largest* salt water lake in the Western Hemisphere, and the *eighth-largest* terminal lake in the world. Although it has been called *America's Dead Sea* , the lake provides habitat for millions of native birds, brine shrimp, shorebirds, and waterfowl, including the largest staging population of Wilson's phalarope in the world. Since 1847, the Great Salt Lake has steadily shrunk, reaching its lowest recorded level in 2016. Today, the lake is 3.6 meters below its 1847 level and just half its original volume.

Keywords Image Processing, Prewitt Edge detection, Delineation

1 Introduction

Natural lakes are generally found in mountainous areas, rift zones, and areas with ongoing glaciation. Other lakes are found in endorheic basins or along the courses of mature rivers. In some parts of the world there are many lakes because of chaotic drainage patterns left over from the last Ice Age. All lakes are temporary over geologic time scales, as they will slowly fill in with sediments or spill out of the basin containing them.
Many lakes are artificial and are constructed for industrial or agricultural use, for hydro-electric power generation or domestic water supply, or for aesthetic, recreational purposes, or other activities.

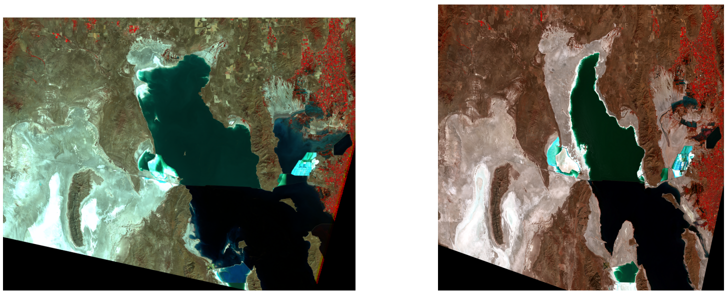
Over the years, surface water bodies like lakes, ponds, reserviors, etc have been treated as a community resource. They were being nurtured, protected, conserved and managed by the major percentage of the local community without any code of conduct or rule. In turn, these water bodies have been catering the local human and livestock populations. In the modern times, after the introduction of public water supply and ground water development through the wells and hand pumps, a dramatic shift in the attitude of the people towards these water bodies has been witnessed. Both locals as well as the government have started neglecting this asset in the fad and fantasy of the introduced public water supply. They have just started ignoring and have really stopped caring and conserving these community resources.

Other than this, mushrooming urban, industrial and infrastructure development has changed the status of these water bodies from community resources to a mere dumping ground or sink for construction debris, garbage, domestic sewage, religious offering etc. These water bodies have fallen a prey to administrative and social atrocities. All this has put the existence of these water bodies on stake and has lead to severe deterioration of their water quality.
In the recent years, urgent need to restore these community resources has been realized by various countries. This is because mushrooming population and development activities have put immense strain on the public water supply and ground water extraction. This has widened demand-supply gap and has lead to excessive depletion of ground water.
The present study deals with the narrowing of one of the major surface water bodies i.e. Lakes. Examining the changes in their overall structure and area done through the graphical analysis of the Landsat images.

1.1 Materials and Methods

The basic methodology adopted for carrying out the present study is primarily by analysing and interpreting the primary data along with the review on the available literature and media reference on the issue. Primary data for the present study are the Landsat images which were gathered from `https://earthexplorer.usgs.gov/` and the literature which was gathered from various sources. The various components of the methodology for the present study are as follows:

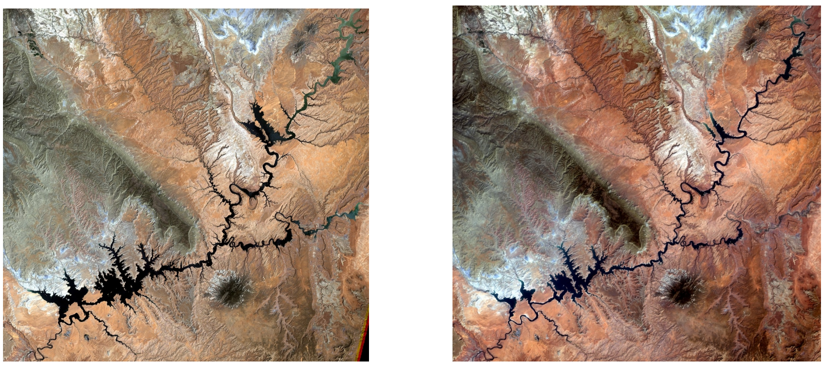
Great Salt Lake: The Great Salt Lake, located in the northern part of the U.S. state of Utah, is the largest salt water lake in the Western Hemisphere, and the eighth-largest terminal lake in the world. In an average year the lake covers an area of around 1,700 square miles (4,400 km2). In 1988 the surface area was at the historic high of 3,300 square miles (8,500 km2) but ever since its surface area has shrunk drastically. In terms of surface area, it is the largest lake in the United States that is not part of the Great Lakes region. Great Salt Lake is salty because it does not have an outlet. Tributary rivers are constantly bringing in small amounts of salt dissolved in their fresh water flow. Once in the Great Salt Lake much of the water evaporates leaving the salt behind.
These dramatic declines in water levels come from years of human activity — namely, diverting river water, which would normally fill the lake, for agriculture and industry. It is estimated that about 40 percent of the river's water is diverted from the lake. These activities, along with the ongoing drought in the West, have drained the historic lake. As a result, evaporation from the lake's surface is considerably outpacing river inflow. As the lake shrinks, wildlife habitat is disappearing and airborne dust from the exposed, dried lakebed threatens the health of the two million people in the surrounding area, including Salt Lake City.



(a) (b)

Fig. 1: Salt Lake in (a) 1999 and (b) 2018

Lake Powell: Lake Powell is a lake near the Colorado river, straddling the border between Utah and Arizona, United States. Most of Lake Powell, along with Rainbow Bridge National Monument, is located in Utah. Colorado River flows in from the east around Mille Crag Bend and is swallowed by the lake. At the west end of Narrow Canyon, the Dirty Devil River joins the lake from the north. It is a major vacation spot that around two million people visit every year. However, due to high water withdrawals for human and agricultural consumption, and because of subsequent droughts in the area, Lake Powell has fallen way below in terms of water, depth and surface area. The declines were first apparent in the side canyons feeding the reservoir which thinned and then shortened. By 2002, the lake level had dropped far enough that the exposed canyon walls created a pale outline around the lake. Dry conditions and falling water levels were unmistakable in the image from April 13, 2003. Lake Powell's side branches had all retreated compared to the previous year's extents. In 2017, snow and rainfall totals were generally low, as the region suffered through a persistent, long-term drought.



(a) (b)

Fig. 2: Lake Powell in (a) 1987 and (b) 2018

Delineation Of Images

When converting an RGB image to grayscale, we have to take the RGB values for each pixel and make as output a single value reflecting the brightness of that pixel. One such approach is to take the average of the contribution from each channel: (R+B+G)/3. However, since the perceived brightness is often dominated by the green component. To avoid that the images were delineated into RGB formats in order to analyse them individually. Normalized-difference vegetation index (NDWI) and Normalized-difference vegetation index MNDWI combine two or more spectral bands using various algebraic operations to enhance the discrepancy between water bodies and land. The principle underlies most WIs is similar to that of the normalized-difference vegetation index. The WIs have been widely used because of their relatively high accuracy in water body detection and their low-cost implementation.

Prewitt Method

Sometimes it happens that the lakes or other water bodies can't be extracted with great accuracy. This might be due to the noise present in the image or the bluriness in the image itself. That's why various edge detection algorithms were used to differentiate the edge of the lakes and the other uneven parts of the images but the Prewiit edge detection method gave the best output. The clear detection and segregation of the edges with their color properties was given by Prewitt method.

Difference in the Images

Lastly two differences were taken for comparing the changes in the surface area of the Lakes which happened over time. The differences are as follows:

- Difference in the original images (Lake Powell in 1984 and Lake Powell in 2018) to see the changes in the overall image.
- Difference in the images obtained after edge detection(rivers abstracted).

The average color of the zones and the brightness were used to compare two pictures for likeness. The basic approach for the same was as follows:

- Check dimensions. If different, then images are not the same.
- Check formats. If same, then Perform precise comparison, pixel by pixel
- If different formats do this: Compare Brightness as half the weight and compare color/hue as the other half . Calculate the difference in values and depending on 'tolerance' value they are the same or they are not.

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2 Results and Discussions

Great Salt Lake

After calculating the differences in the original images and the images obtained after Prewitt detection were analysed, the changes in the surface area was calculated over the years. The results were as folllows:

>Change in the surface area from 1987 to 1999 :- ***-18.06%***
>Change in the surface area from 1999 to 2011 :- ***-13.34%***
>Change in the surface area from 2011 to 2016 :- ***-21.74%***
>Change in the surface area from 2016 to 2018 :- ***-10.65%***

The overall change observed from 1987 to 2018 was ***-56.07%***

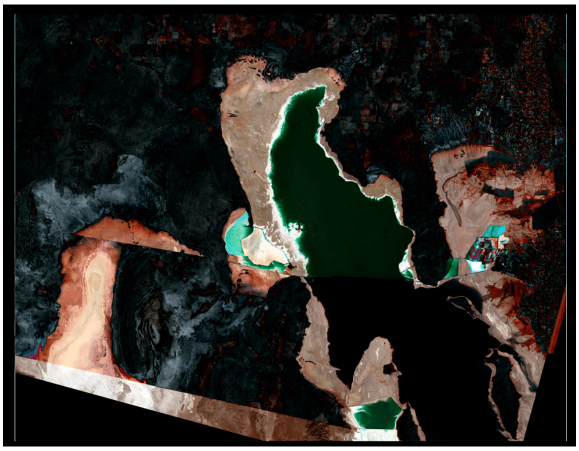

Fig. 3: Differences in the original images of 1987 and 2018

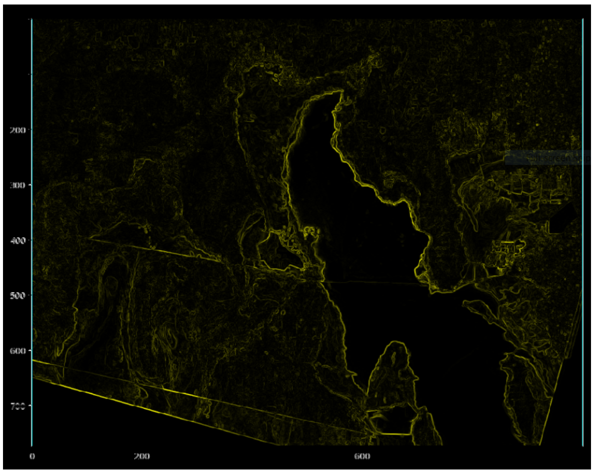

Fig. 4: Differences in the images after Prewitt Detection

Lake Powell
After calculating the differences in the same way as described above. The results were as folllows:
>Change in the surface area from 1984 to 1993 : ***-12.47%***
>Change in the surface area from 1993 to 1998 : ***-26.56%***
>Change in the surface area from 1998 to 2018 : ***-36.05%***
The overall change observed from 1984 to 2018 was ***-58.76%***

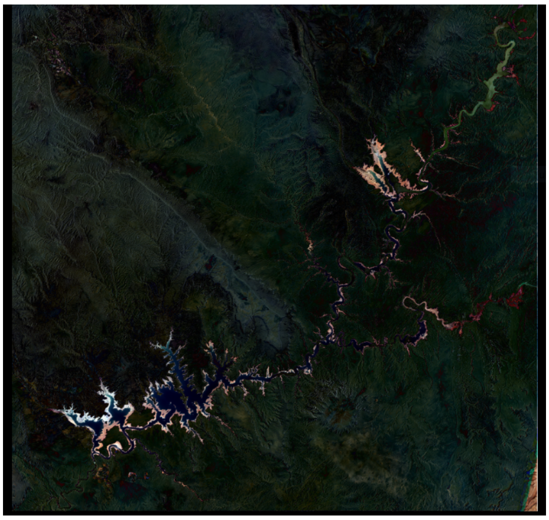

Fig. 5: Differences in the original images of 1984 and 2018

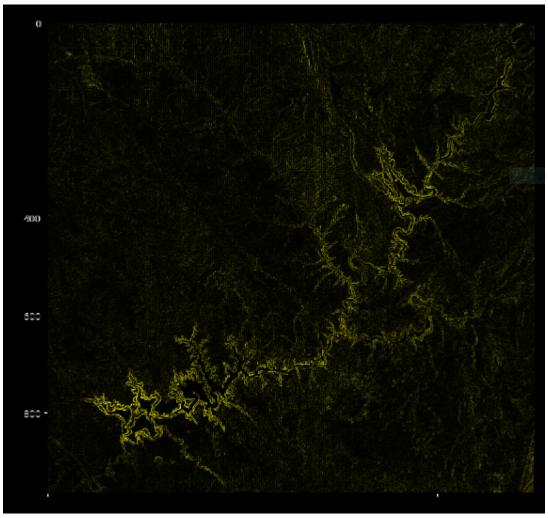

Fig. 6: Differences in the images after Prewitt Detection

3 Summary and Discussions

There are several difficulties associated with water body extraction from satellite imagery using water indices (WIs) that are based on the thresholding method, including: (1) inefficient identification of mixed water pixels; (2) confusion of water bodies with background noise; and (3) variations in the optimal water extraction threshold that depend on the characteristics of an individual scene. Landsat imaging and water quality monitoring are of vital imperativeness as it gives particular data about the quality and the nature of the water bodies. The NDVI was developed mainly for separating green vegetation from other surfaces. However, it did perform well for surface water detection. The water features enhanced using the NDWI are often mixed with built-up land and the area of extracted water can be overestimated. The MNDWI was developed to modify the NDWI in detecting water features for water regions with backgrounds dominated by built-up land areas. In this study, the NDWI performed significantly better compared with other indexes for mapping lake water surface using Landsat data. The proposed approach has the advantage of simultaneously detecting the surface water changes of multi-temporal images (between two and three different times).

As shown in the study, Lake Powell and Great Salt Lake lost more than half of its surface area in the period 1984–2018 and 1987-2018 respectively . If this trend continues, it is very likely that the lakes will lose all of their surface area in the near future. This is very critical because the lakes provide many benefits for the society and the people living in their surroundings. Therefore, appropriate measures need to be taken by policy makers to prevent further decline of these lakes surface area and to restore the lakes to their original condition. It is evident that constructing dams on the rivers flowing to the lakes, excessive ground water exploitation, devoting water sources to agricultural, industrial and domestic uses, and long periods of drought have all reduced the surface area of these lakes. Further, the changes to water supply and extraction from the catchment such as the changes in rainfall and agricultural land use over the time period should be investigated.

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