Analysis and 2D, 3D visualization for a long term of Typhoon data

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***Abstract*—This paper aims to discover valuable meteorological typhoon data from the weather center, analyzing the raw data to generate the 2D and 3D visualization data using visualization techniques such as heat map, vector field, and uncertainty visualization. Based on the visual information to create the typhoon tracking map. Finally, we can recognize the motion of typhoons and forecasting to next movement from visualization data.**

1. Motivation

Natural disasters, such as firestorms, dust storms, floods, hurricanes, tornadoes, volcanic eruptions, earthquakes, typhoons, tsunami, have a massive impact on our lives. Approximately 60,000 people globally die from natural disasters each year, representing 0.1% of global deaths [1]. Not only for the people's lives but also damage to the natural environment on our planet. As we know that natural disasters are out of human control, they are all unpredictable and uncertain. Although we cannot estimate the natural disasters in our lives, they must have an initiating event point. If we can recognize the initial event point, also we have long-term meteorological data. Based on the raw data, we can analyze the natural motion of the disasters to predict the next movement for protecting our lives.

2. Related Work

In general, there are four visual pipeline stages in processing for visualization. The first stage is data acquisition measures the physical phenomenon or physical property, and the second stage is the process derivation and transformation; the third stage is the rendering. Finally, analysis all raw data to visually person is looking the visual information.

To better understand how to data mining from the raw data, what kind of visualization method to apply to the raw data for generating the 2D and 3D visualization data. We first must understand how current 2D, 3D visualization methods work for meteorological data visualization and forecasting systems, what technologies currently exist for 2D, 3D visualization. Therefore, preliminary research is needed better to understand the underlying causes of the visualization method.

Ueng , and Sikorski, and Kwan-Liu [3] are to develop the new computational techniques include a specialized version of the Runge-Kutta method, to demonstrate the time efficiency of the new particle tracking algorithm, which applies to the meteorological data to effectively visualizing the fluid motion in steady flows. However, the movement of a typhoon depends on the situation of the environment, such as sea temperature, sea-level pressure, etc. therefore, there are uncertain fluid motions that exist on the motion of typhoons.

Boller et al. [4] use the fourth-order Runge-Kutta numerical integration, with fixed step size and linear interpolation over the discrete data to generate the uncertainty estimation into the visualization of trajectories. This technique may be applied to the typhoon tracking map to make it more accurate forecasting.

Recently, current visualization technology has improved significantly, especially the graphical processing unit (GPU), which is accelerating to a powerful device. Nicolas et al. [6] apply the GPU-based particle systems to visualize the dynamic flow and demonstrate the framework using the flow data of a typhoon simulation.

Not only for the Hardware but also the visualization software will improve a lot. Liu, Gong, and Yu propose [5] using a systematic meteorological data visualization (MDV) framework in World wind, an open-source virtual globe. The authors believe that the application can be an effective tool for meteorological data visualization and analysis. They provided the simulation of typhoon tracking animation.

Nakano et al. [2] use the long-term meteorological typhoon data to improve typhoon forecast, they are using the Double Fourier Series Model (DFSM), the Multi-Scale Simulator for the Geoenvironment (MSSG), and the Nonhydrostatic ICosahedral Atmospheric Model (NICAM), Global Spectral Model (GSM) of the Japan Meteorological Agency to compare the track prediction.

3. proposed research directions

The raw data is gathering from the National Hurricane Center, and Central Pacific Hurricane Center, Joint Typhoon Warning Center. Those weather centers are correct the live and long term (1945 to 2020) of meteorological data from

the Southern Hemisphere, Northern, Indian Ocean, and Western North Pacific Ocean. The direction of the proposed research is step by step to visualize the typhoon data:

1. we need to do data mining for the necessary data for the visualization, re-labeling, and then applying the heat map to 2D and 3D visualization from the raw data to analyze which features are useful for using the typhoon tracking map and forecasting.

2. the typhoon has a vector movement. Therefore, we must apply the vector field visualization method such as the fourth-order Runge-Kutta method and find the other vector field visualization methods.

3. uncertainty also exists on the locomotion of the typhoon; accordingly, we have to consider the uncertainty visualization method.

4. all methods put together and generating the typhoon tracking map and forecasting.

4. Methods

In this section, we will discuss the visualization method for Typhoon tracking map and forecasting. Before we apply our visualization methods, data mining and re-labeling are going to require gathering meaningful data. According to the Joint Typhoon Warning Center (JTWC), they separated by three-ocean area for correcting the typhoon data; Southern Hemisphere, Northern Indian Ocean, and Western North Pacific Ocean. As shown in Figures 1,2 and 3 represent how often the typhoon is generated from each region per year from 1945 to 2020.

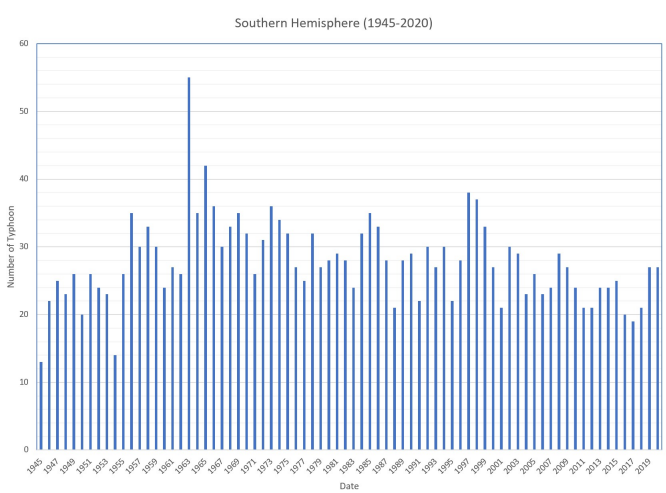

Figure 1. Southern Hemisphere(1945-2020)

However, Some data is missing from 1945 to 1979, like latitude and longitude, wind speed, mean sea pressure level, and wind direction. Therefore, we can't generate the visualization data from 1945 to 1979, and also, some missing data is going to use from another data center, which is National Oceanic and Atmospheric Administration (NOAA). The following subsection is going to use the data from 1980 to 2020 for generating the 2D heatmap.

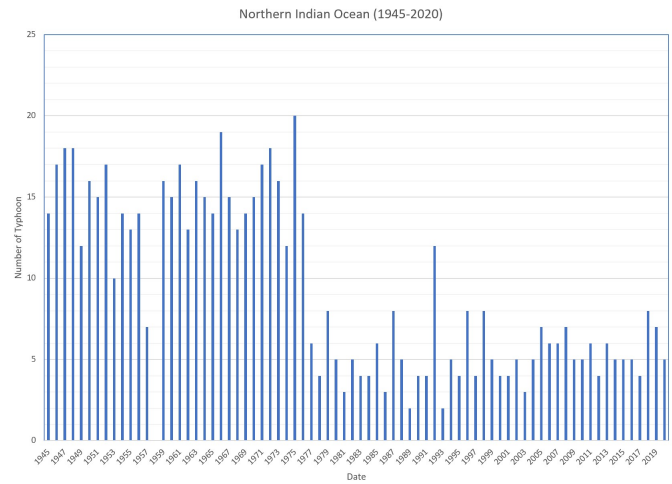

Figure 2. Northern Indian Ocean(1945-2020)

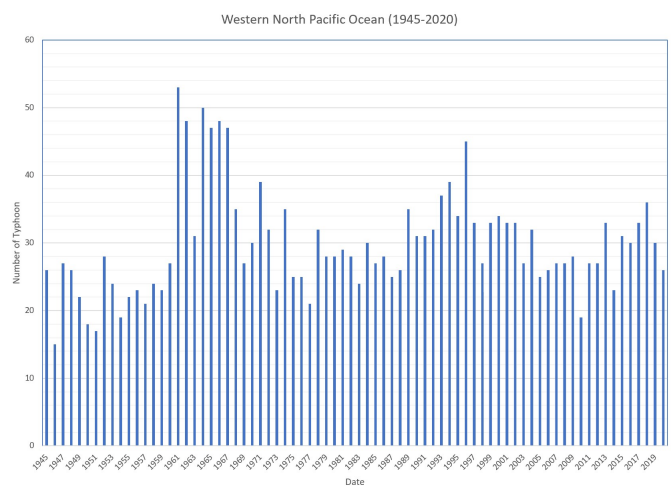

Figure 3. Western North Pacific Ocean(1945-2020)

Figure 4. 2D heatmap of Typhoon tracking

4.1. Heat map

Heatmap is the one of visualization technique that the data in 2-dimensional format in the form of colored maps. We are going to use the meteorological data from Joint Typhoon Warning Center(JTWC) and National Oceanic and Atmospheric Administration (NOAA).

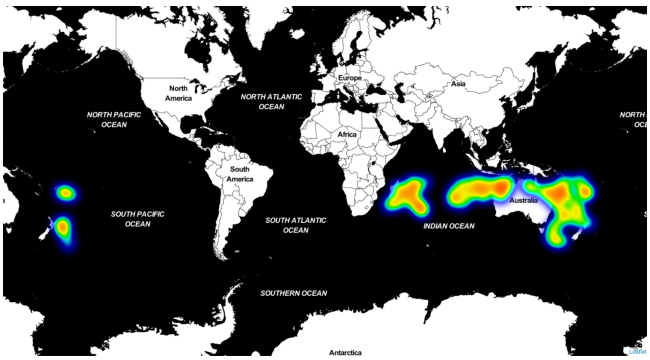

Figure 5. 2D heatmap of Typhoon tracking

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