

**Department of Computer Science**  
**University of Hong Kong**  
**Final Year Project**

**Typhoon Track Predictor**  
**Project Plan**

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## Change History

Issue	Date	Description
1.0	29/9/2019	First Issue

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## 1. Project Introduction

The following is a plan and introduction to a track predictor of typhoons, which is known as tropical cyclones and related meteorological phenomenon.

Tropical cyclones are low pressure systems that originates over tropical seas. Generally, tropical cyclones are formed, fuelled and remained by warm, moist air over the tropical oceans. Tropical oceans' surface layer are heated by solar radiation directly. The warm, moist air rises and condenses at higher position to release latent heat which contributes to higher mechanical energy and wind speed. The air pressure over the heated oceans' surfaces is lowered which attracts inflow of cooler, higher pressure and denser air from the surroundings. Thus a convection is engaged and becomes the heat engine of a tropical cyclone. The system spins as it is forced by the Coriolis force due to the earth's rotation.

There are six environmental conditions which are considered as necessary for a tropical cyclone to be formed. Such conditions are (1) sufficiently warm sea waters and air which rises to fuel the heat engine of the tropical cyclone, (2) atmosphere that cools rising air fast to make air condenses and support convection, (3) moist air at the mid level of the system, (4) sufficiently distant from equator such that the Coriolis force is large enough to spin the system, (5) a pre-existing system of circulation and low-level inflow for the tropical cyclone to develop on and (6) absence of strong vertical wind shear that may disturb the convection <sup>1</sup>.

There are several possible causes for a tropical cyclone to decay, such as (1) upwelling produced by erratic movement of the winds, which extracts cooler water to the system and weakens the tropical cyclones, (2) inflow of dry air which reduces condensation and disrupts the convection effect, (3) moving over cooler water surfaces where the supply of warm, moist air decreases or (4) landfall of the system

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<sup>1</sup> NOAA's Atlantic Oceanographic and Meteorological Laboratory. How do tropical cyclones form?  
Retrieved from <https://www.aoml.noaa.gov/hrd/tcfaq/A15.html>

where the system leaves the supply of warm water surfaces etc <sup>2</sup>. Such events lead to the depletion of energy of the tropical cyclone and results in cyclone's decay.

Tropical cyclones may cause serious destruction with strong, high speed winds, heavy rainfall and its following flooding. The strike of strong typhoon always results in damage to property, injuries and even deaths. It is necessary to have tropical cyclone prediction systems which are able to give accurate predictions and safety measure taken according to the predictions.

There are three main types of forecast model currently implemented to predict intensity and track of tropical cyclones. They are (1) dynamic models which employs physical equations and (2) statistical models based on historical data which imply relationships between cyclone behavior and its different attributes and (3) combined models with both dynamic and statistical techniques<sup>3</sup>. Statistical models generally do not consider the current physical environment but the historical events.

This project aims to produce a statistical model which focuses on the prediction of typhoon tracks, using machine learning techniques. It is supposed to train neural networks with historical data of past tracks data as training data.

Literatures of recently developed models were consulted. Giffard-Roisin, S, Yang, M, Charpiat G, Kég, B and Claire, M (2018) have developed a fused model which were built with a neural network of past tracks and convolutional neural network of wind fields.<sup>4</sup> Rüttgers, M, Lee, S, Jeon, S, and You, D (2019) have developed

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<sup>2</sup> Edwards, J. 1995. Tropical Cyclone Formation. HurricaneZone.net. Retrieved from <https://www.hurricanezone.net/articles/tropicalcycloneformation.html>

<sup>3</sup> National Hurricane Center. 2019. NHC Track and Intensity Models. Retrieved from <https://www.nhc.noaa.gov/modelsummary.shtml>

<sup>4</sup> Giffard-Roisin, S, Yang, M, Charpiat, G, Kég, B & Claire, M. 2018. Fused Deep Learning for Hurricane Track Forecast from Reanalysis Data. Climate Informatics Workshop Proceedings 2018, Sep 2018, Boulder, United States. fhal-01851001

a model using generative adversarial network with satellite images<sup>5</sup>. In this project, using neural network techniques, a new set of training data will be used to develop the predictor model. The trained model is supposed to give predicted positions of a tropical cyclone at next timestamps when set of previous positions are input.

## 2. Project Objectives

Using neural networks, the primary objective of the project is to predict the future motion of a tropical cyclone when its previous path and positions are given as input. The predicted track can be referenced to give possible answers to some questions related to that tropical cyclone, such as which regions or countries is that tropical cyclone possible to affect, or how likely that tropical cyclone will arrive of effect particular regions or countries.

Specifically, the main objectives for this project are:

- Take cyclone trajectory (in the form of sequences of position (latitude, longitude, timestamp) points) as input, perform predictions and give “future” positions at several future timestamps.
- Graph the prediction trajectory to make it a readable cyclone track.

The product software is required to take input in different formats and turns to be useful data (typhoon center positions) for prediction work. The neural network will be trained with large amount of such data in order to make the network able to perform track prediction according to historical experience. The predicted track data should be plotted to create graphic presentations.

The model’s performance training method is supposed to be examined with tests in order to evaluate the training method used. Test reports will be produced in details and comparison to existing

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<sup>5</sup> Rüttgers, M., Lee, S., Jeon, S., & You, D. (2019). Prediction of a typhoon track using a generative adversarial network and satellite images. *Scientific reports*, 9(1), 6057.  
doi:10.1038/s41598-019-42339-y

models are supposed to perform.

### 3. Project Methodology

The following is a brief discussion about the method to take.

The training data will be extracted from historical track data provided by several meteorological centers.

#### Extraction of data

**RSMC Tropical Cyclone Best Track Data in 2017**

Date/Time (UTC)	Center position Lat (N) Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
<b>Muifa (1701)</b>					
Apr. 22/18	8.6 143.9	1006	-	0.5	TD
23/00	9.2 143.2	1006	-	0.5	TD
23/06	9.9 142.4	1006	-	0.5	TD
23/12	10.6 141.7	1006	-	1.0	TD
23/18	11.2 140.8	1006	-	1.0	TD
24/00	11.8 139.7	1006	-	1.0	TD
24/06	12.1 138.8	1004	-	1.0	TD
24/12	12.4 138.2	1004	-	1.0	TD
24/18	12.5 137.5	1004	-	1.5	TD
25/00	12.7 137.0	1004	-	1.5	TD
25/06	12.8 136.6	1004	-	2.0	TD
25/12	12.9 136.4	1004	-	2.0	TD
25/18	13.1 136.0	1002	35	2.5	TS
26/00	13.2 135.7	1002	35	2.5	TS
26/06	13.6 134.8	1002	35	2.5	TS
26/12	14.0 134.4	1002	35	2.5	TS
26/18	14.4 134.4	1002	35	2.5	TS
27/00	14.8 134.4	1002	35	2.5	TS
27/06	15.9 134.7	1004	-	2.5	TD
27/12	17.0 134.7	1006	-	2.0	TD
27/18	17.8 134.8	1006	-	-	TD
28/00	18.4 135.5	1008	-	-	TD
28/06	19.0 136.3	1008	-	-	TD
28/12	19.9 137.7	1008	-	-	TD
28/18	20.8 139.0	1008	-	-	TD
29/00	21.5 140.2	1008	-	-	TD
29/06	22.7 141.8	1008	-	-	TD
29/12					Disapp.
<b>Nanmadol (1703)</b>					
Jul. 01/06	15.0 132.2	1006	-	0.5	TD
01/12	16.8 130.5	1006	-	1.0	TD
01/18	18.8 128.9	1006	-	1.5	TD
02/00	20.7 127.1	1002	35	2.0	TS
02/06	21.9 125.7	1002	35	2.0	TS
02/12	23.5 124.8	998	40	5.5	TS
02/18	24.7 124.1	990	50	3.0	STS
03/00	26.2 124.3	990	50	3.0	STS
03/06	27.7 125.0	985	55	3.0	STS
03/12	29.4 126.2	985	55	3.5	STS
03/15	30.2 126.9	985	55	-	STS
03/18	31.3 127.7	985	55	3.5	STS
03/21	32.1 128.9	985	55	-	STS
03/23	32.7 130.0	985	55	-	STS
04/00	32.8 130.5	990	50	3.5	STS
04/03	33.2 132.3	990	50	-	STS
04/06	33.6 134.2	990	50	3.0	STS
04/07	33.7 134.8	990	50	-	STS
04/09	34.1 136.5	990	50	-	STS
04/12	34.1 138.3	990	50	3.0	STS
04/15	34.7 140.2	990	50	-	STS
04/18	35.5 142.6	990	50	3.0	STS
05/00	36.1 146.0	994	-	3.0	L
05/06	36.9 150.7	994	-	-	L
05/12	38.2 154.8	994	-	-	L
05/18	40.3 160.2	994	-	-	L
06/00	43.0 166.1	992	-	-	L
06/06	46.4 169.9	988	-	-	L
<b>Noru (1705)</b>					
Jul. 19/06	26.1 162.1	1010	-	0.5	TD
19/12	26.2 161.7	1010	-	1.0	TD
19/18	26.4 161.2	1008	-	1.5	TD
20/00	26.9 160.6	1008	-	1.5	TD
20/06	27.2 159.9	1008	-	1.5	TD
20/12	27.4 159.0	1006	35	2.0	TS
20/18	27.6 158.4	1006	35	2.0	TS
21/00	28.0 157.5	1006	35	2.0	TS
21/06	28.2 156.6	1006	35	2.0	TS
21/12	28.3 155.5	1004	35	2.0	TS
21/18	28.5 154.3	1000	40	2.5	TS
22/00	28.6 153.7	1000	40	2.5	TS
22/06	28.7 153.2	998	40	2.5	TS
22/12	28.7 152.5	994	45	3.0	TS
22/18	28.6 151.9	990	50	3.5	STS
23/00	28.3 151.4	985	55	3.5	STS
23/06	28.1 151.2	980	60	4.0	STS
23/12	28.0 151.4	975	65	4.5	TY
23/18	27.6 151.6	975	65	4.5	TY
24/00	27.2 152.2	970	70	5.0	TY
24/06	26.7 153.0	970	70	5.0	TY
24/12	26.2 154.1	970	70	5.0	TY
24/18	25.9 155.5	970	70	5.0	TY
25/00	25.7 156.7	970	70	5.0	TY
25/06	25.9 157.6	970	70	5.0	TY
25/12	26.2 158.2	975	65	4.5	TY
25/18	27.0 158.4	975	65	4.5	TY
26/00	28.0 157.9	975	65	4.5	TY

Figure 1. Best Track Data Extracted from annual report of RSMC (The Regional Specialized Meteorological Center Tokyo) in 2017. The tropical cyclones captured are Mufia(1701), Nanmadol(1703) and Noru(1705).

The above figure shows part of the Best Track Data provided by RSMC, the meteorological center of Japan. Track data, including center positions (latitude, longitude) at each timestamp are given in detail. Such data are supposed to be collected and organized in a united form as a set of training data. Design of data format conversion is required to support input in special formats such as KML file(Google Earth format)

The neural network is trained and tested repeatedly with large amount of training data. It should be tested and examined periodically during training in order to have review on training strategy (e.g. selection of cyclone attributes).

When the trained model is able to give effective predictions, such

output data are supposed to provide in both numeric and graphical format. It is considered that the prediction result can be in special format that is applicable on some map reader software (e.g. KML format and Google Earth)

#### 4. Project Schedule and Milestones

The project schedule is planned according to the tentative schedule provided by the department of Computer Science.

29 September 2019	Deliverables of Phase 1 (Inception) <ul style="list-style-type: none"> <li>Detailed project plan</li> <li>Project web page</li> </ul>
October - mid November 2019	<ul style="list-style-type: none"> <li>confirmation on the complete workflow and all tools required of model training.</li> <li>training data collection and selection</li> <li>production of a prototype predictor model</li> </ul>
mid November - January 2019	<ul style="list-style-type: none"> <li>model training</li> <li>create simple API for model testing and presentation</li> <li>model test</li> </ul>
13-17 January 2020	First presentation
2 February 2020	Deliverables of Phase 2 (Elaboration) <ul style="list-style-type: none"> <li>Preliminary implementation</li> <li>Detailed interim report</li> </ul>

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February - April 2020	<ul style="list-style-type: none"> <li>• refinement on trained model</li> <li>• Model test and evaluation</li> <li>• Complete API for project exhibiton and presentation</li> <li>• Preparation of final report</li> </ul>
19 April 2020	Deliverables of Phase 3 (Construction) <ul style="list-style-type: none"> <li>• Finalized tested implementation</li> <li>• Final report</li> </ul>
20-24 April 2020	Final presentation
5 May 2020	Project exhibition
3 June 2020	Project competition (for selected projects only)

## 5. Reference

1. Edwards, J. 1995. Tropical Cyclone Formation. HurricaneZone.net. Retrieved from <https://www.hurricanezone.net/articles/tropicalcycloneformation.html>
2. Giffard-Roisin, S, Yang, M, Charpiat, G, Kég, B & Claire, M. 2018. Fused Deep Learning for Hurricane Track Forecast from Reanalysis Data. Climate Informatics Workshop Proceedings 2018, Sep 2018, Boulder, United States. ffhal-01851001
3. National Hurricane Center. 2019. NHC Track and Intensity Models. Retrieved from <https://www.nhc.noaa.gov/modelsummary.shtml>
4. NOAA's Atlantic Oceanographic and Meteorological Laboratory. How do tropical cyclones form? Retrieved from <https://www.aoml.noaa.gov/hrd/tcfaq/A15.html>



5. Rüttgers, M., Lee, S., Jeon, S., & You, D. (2019). Prediction of a typhoon track using a generative adversarial network and satellite images. Scientific reports, 9(1), 6057. doi:10.1038/s41598-019-42339-y
6. RSMC Tokyo. 2017. Annual Report on the Activities of the RSMC Tokyo - Typhoon Center 2017. Retrieved from <https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/AnnualReport/2017/Text/Text2017.pdf>