

The Application of Artificial Intelligence to Causal Analysis of High G Landing Event — EVA's Perspective and Practice



Tamkang
University

Presented by
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AI is reshaping the Aviation Industry

AI is our opportunity window for Now & Future!

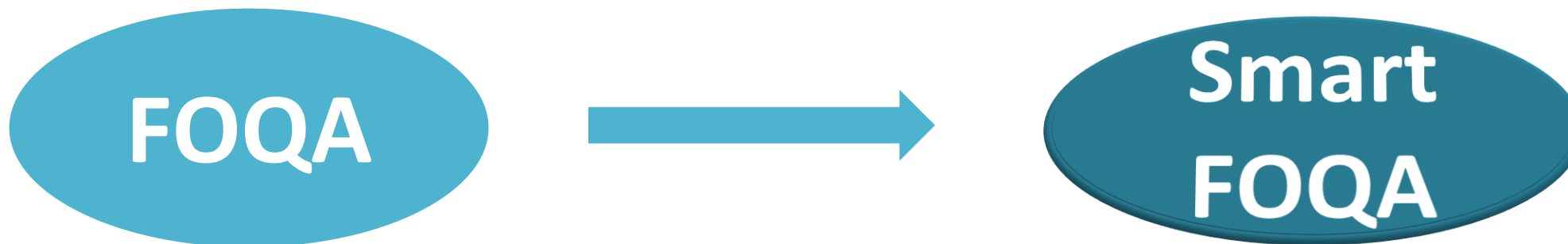
AI applications

- Boeing Jeppesen : AI based crew rostering system.
- Delta : AI based predictive maintenance.
- Airbus : AI Gym program

How about the application of AI in FOQA?

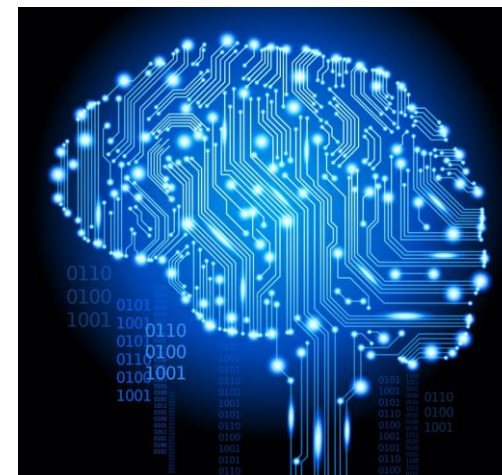


Objective



Smart FOQA

To automate the causal analysis of FOQA events via the application of AI.





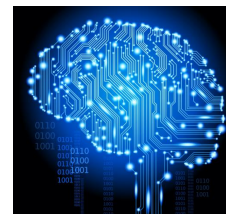
**WGL Comm+™
System(WQAR)**



**Telecom
Services**



**FDM
&
Data
Analysis**



**FOQA
Report**



**Crew
Awareness**



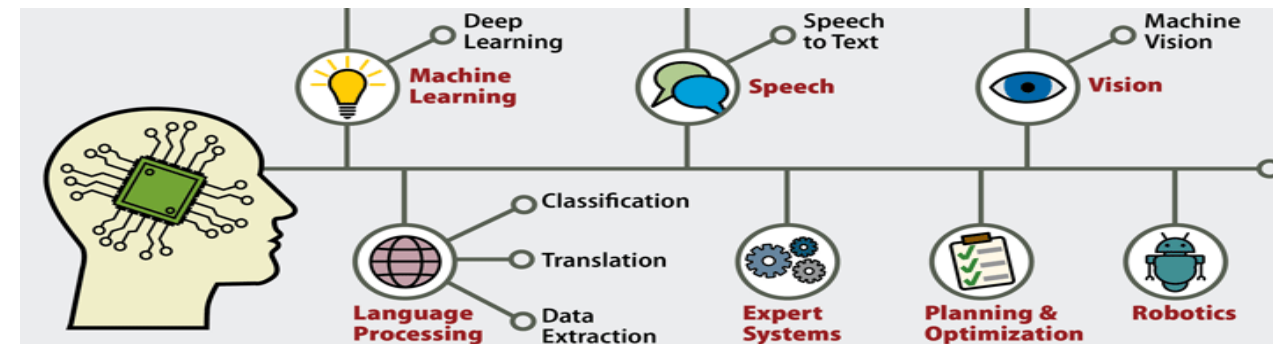
**Trend
Analysis**

Our 1ST Step

- EVA partner with Tamkang University and CYCU to launch the subject study since Feb 2017.
- High G landing event is selected.

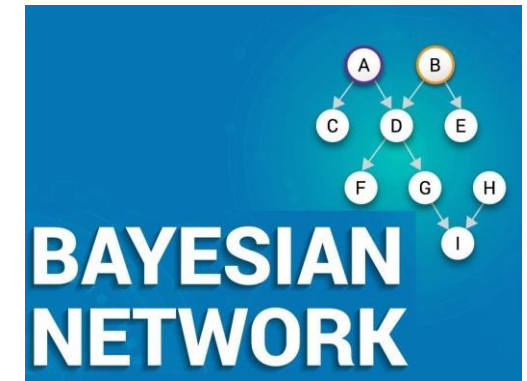
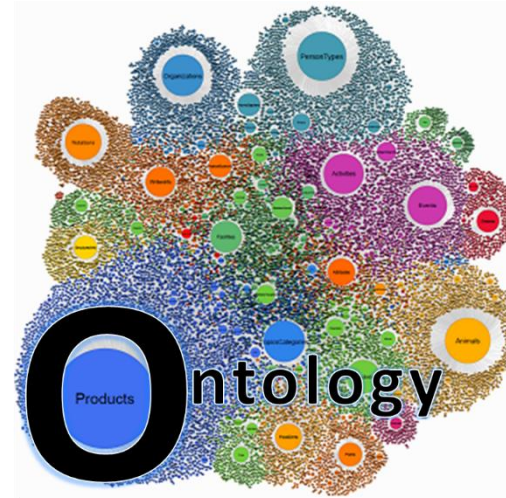
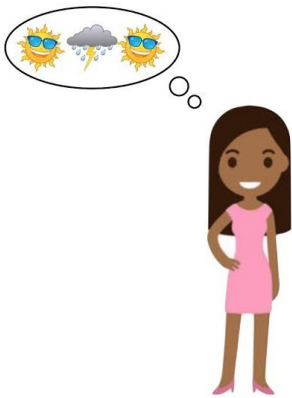
High G Landing Event

If the maximum G load at main gear exceeded preset threshold.



The Journey...

Hidden Markov Model



Sequential state modeling

- How to define states?
- Multi-dimensional data?

Knowledge representation

- Static model
- Linking to QAR?

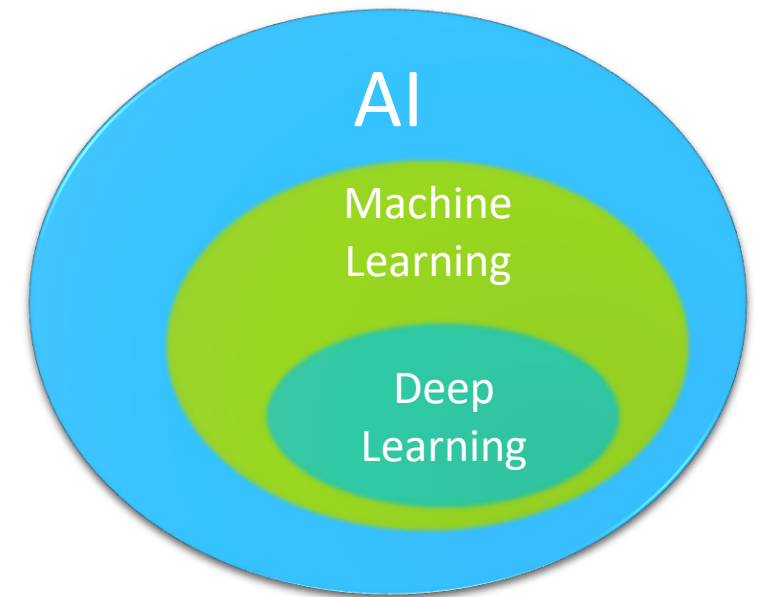
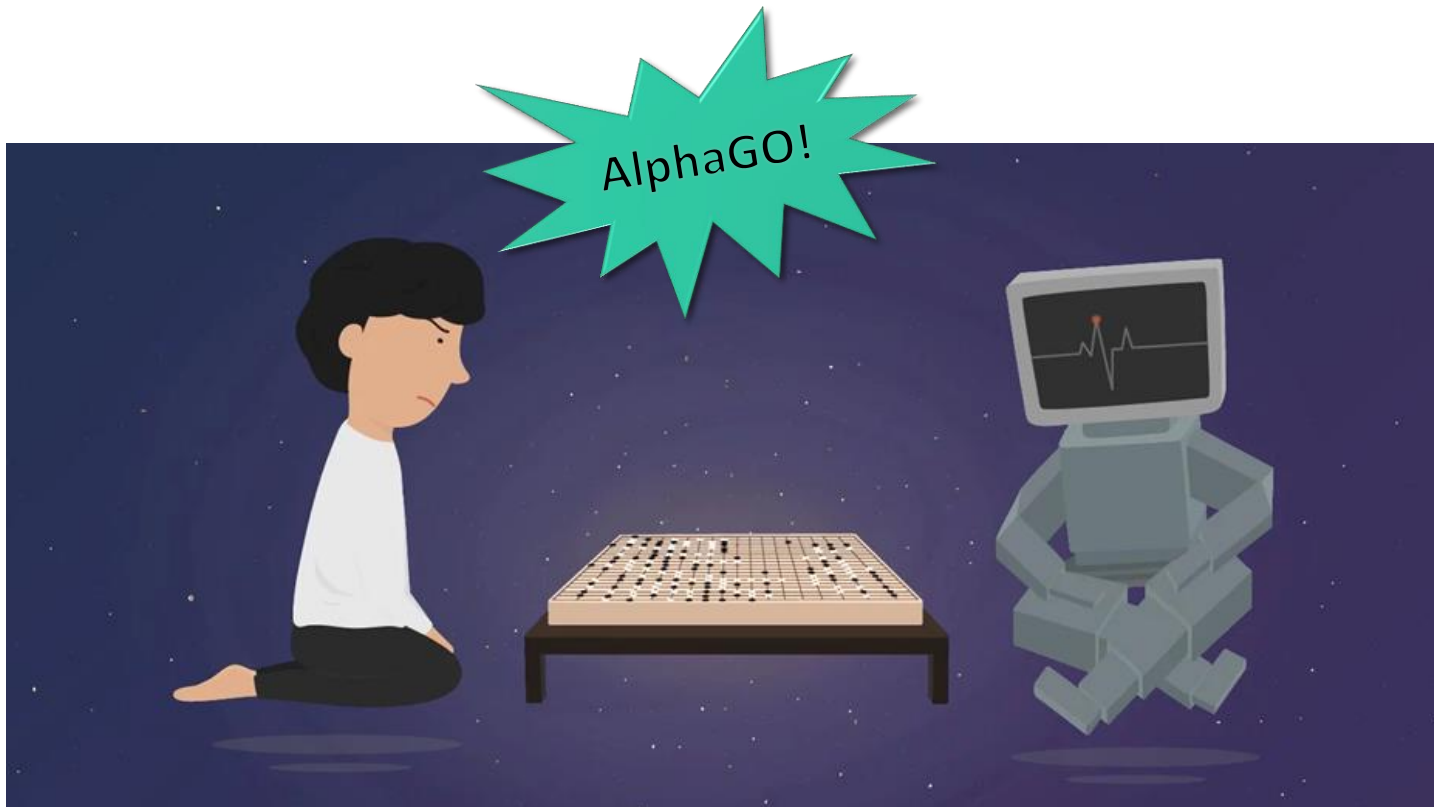
Causal relation modeling

- Time aspect?
- Probability estimation?

The Chosen One - Long Short-term Memory (LSTM)

Deep Learning

- Part of a broader family of **machine learning** methods based on **artificial neural networks**.



Long Short-term Memory (LSTM)

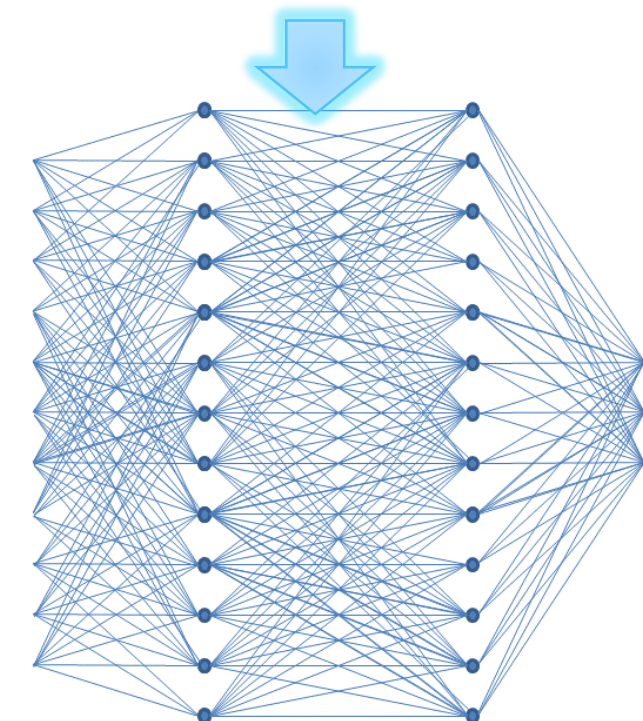
A kind of **Artificial Neural Networks**

Capable of learning and maintaining a set of memory cells over time

Ideal for modeling time series data

QAR is multiple-dimensional time series data

Time	RA	Pitch	V/S	N1	...
50796.00	179	1.14	600	54.44	
50796.10	168	0.83	640	54.62	
50796.20	158	0.88	688	55.25	
50796.25	132	1.01	712	55.50	



Selected Features from QAR data

Features

Control column
position

Ground speed

Pitch attitude

Radio height

Vertical speed

Calibrated air speed

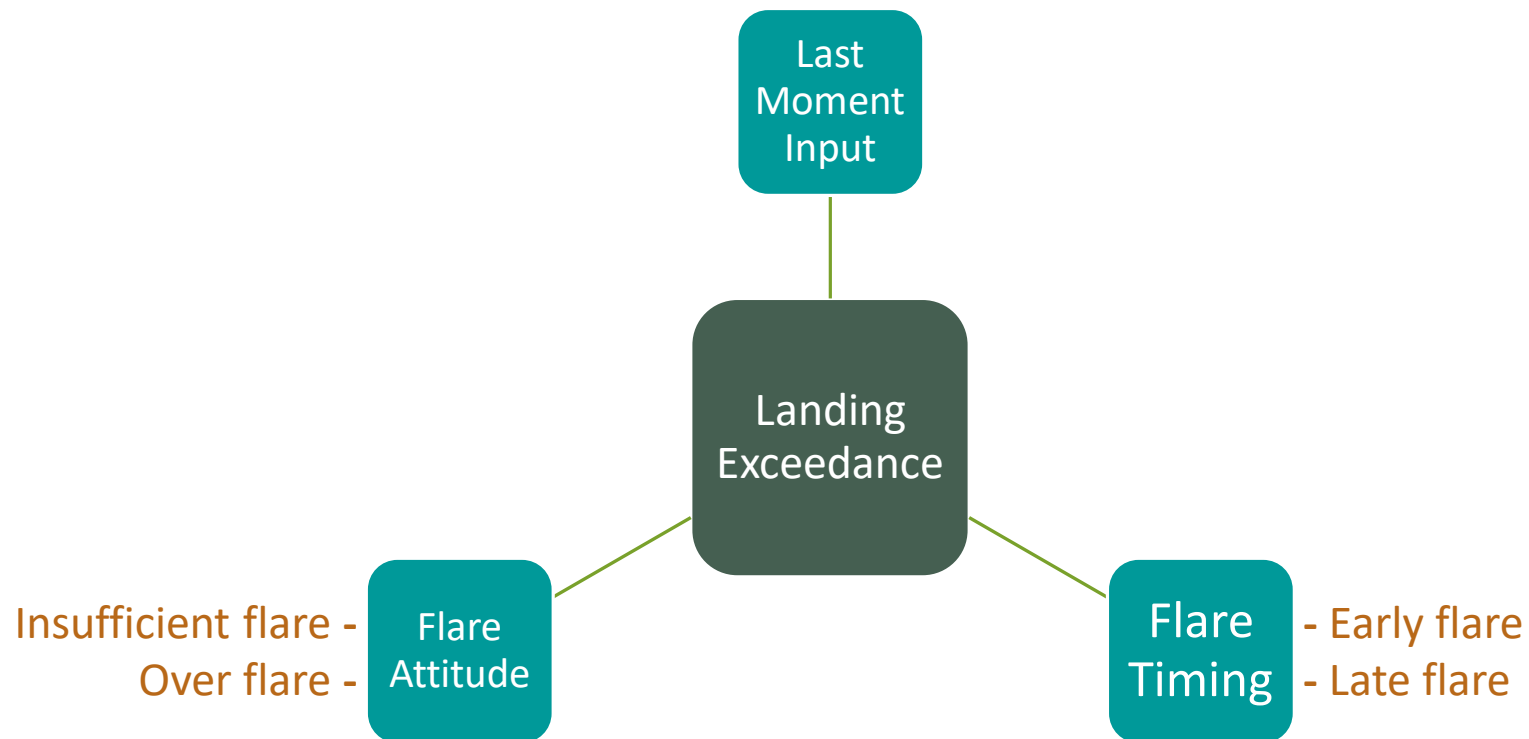
N1

Feature: The necessary parameters to describe a record

Cause Grouping

Group	Cause	Definition
flare attitude	Insufficient flare	The flare maneuver fails to maintain a proper pitch attitude (i.e. insufficient pitch angle), and hence unable to reduce the vertical speed to an acceptable range and cause a firm landing.
	Over flare	An over pull of the control column and hence producing an exceeding pitch angle, which results in insufficient power and cause a firm landing.
flare timing	Late flare	Flare begins below a normal flare height, and hence unable to reduce the vertical speed to an acceptable range and cause a firm landing.
	Early flare	Flare begins above a normal flare height. As a result, the speed is insufficient to provide enough power and hence cause a firm landing.
control input	Last moment input	At the last moment of landing, a sudden pull of control column results in a rapid change in the pitch attitude.

Analytical Models



Causal Analysis Models

Inputs (Features)

COL POS 
G/S 
Pitch 
RA 
V/S 
A/S 
N1 

Models

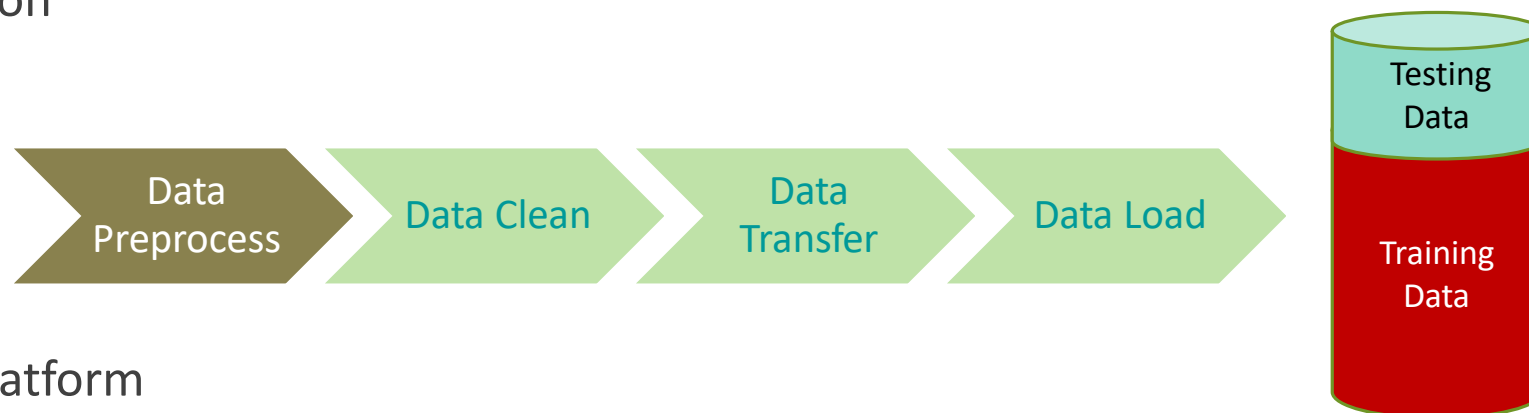


Outputs (Causes)

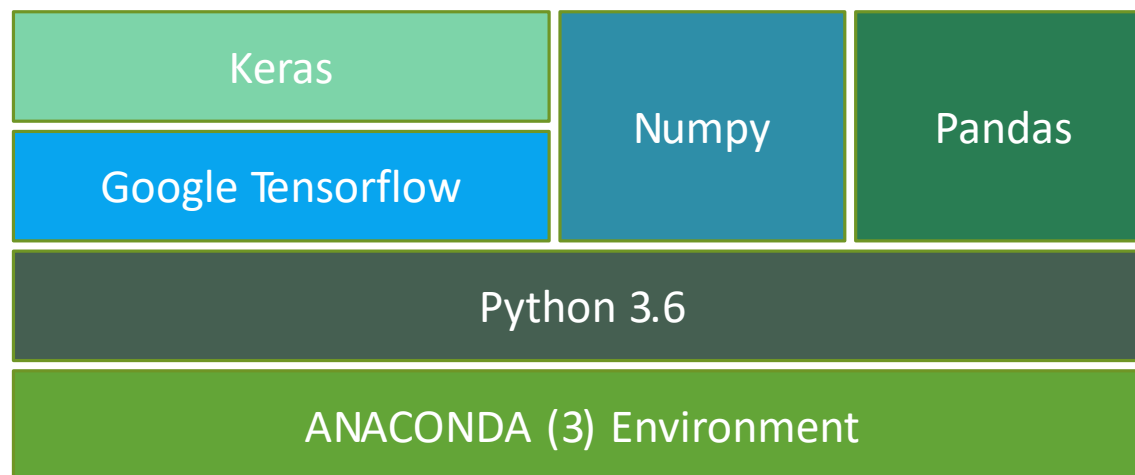


Implementation

Data procession

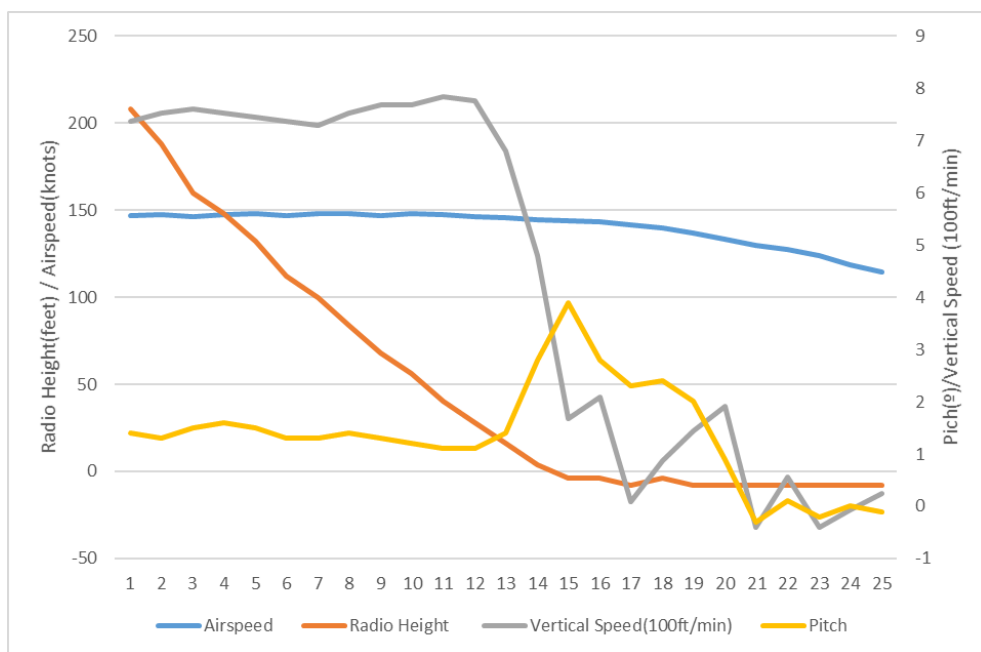


Computing platform



Example B777-300ER

AI Analysis of the event flight



Identified by LSTM as **Insufficient** and **Late Flare**

Analysis of Safety Pilot

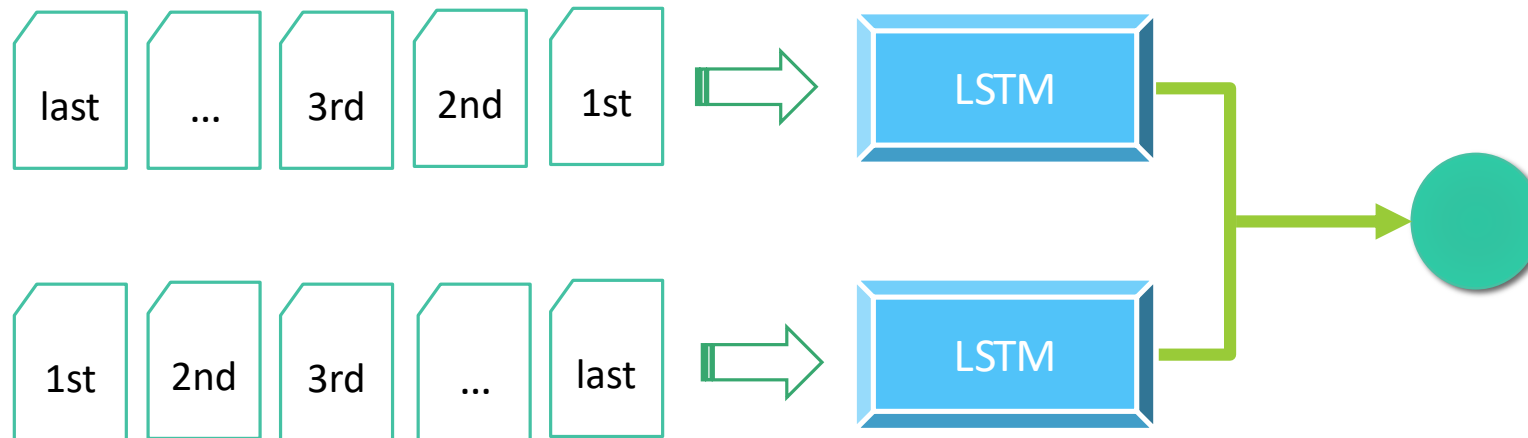
RA	PTCH	IVV
68	U1.3	-768
56	U1.2	-768
40	U1.1	-784
28	U1.1	-776
16	U1.4	-680
4	U2.8	-480
T/D	U3.9	-168

The probable causes:

The flare was initiated late and the pitch remain increasing during touchdown which created high main gears sink rate and high normal acceleration .

Bi-direction LSTM (BLSTM) – a Variant of LSTM

The performance of time-series-based prediction can be enhanced if the system is modeled with both forward and backward temporal perspectives



Performance Comparison

Models	MLR			BPN			LSTM			BLSTM		
	P	T	L	P	T	L	P	T	L	P	T	L
Training Accuracy	0.73	0.75	0.70	0.71	0.74	0.72	0.83	0.83	0.80	0.88	0.90	0.81
Testing Accuracy	0.56	0.62	0.61	0.64	0.63	0.68	0.71	0.73	0.78	0.71	0.83	0.79

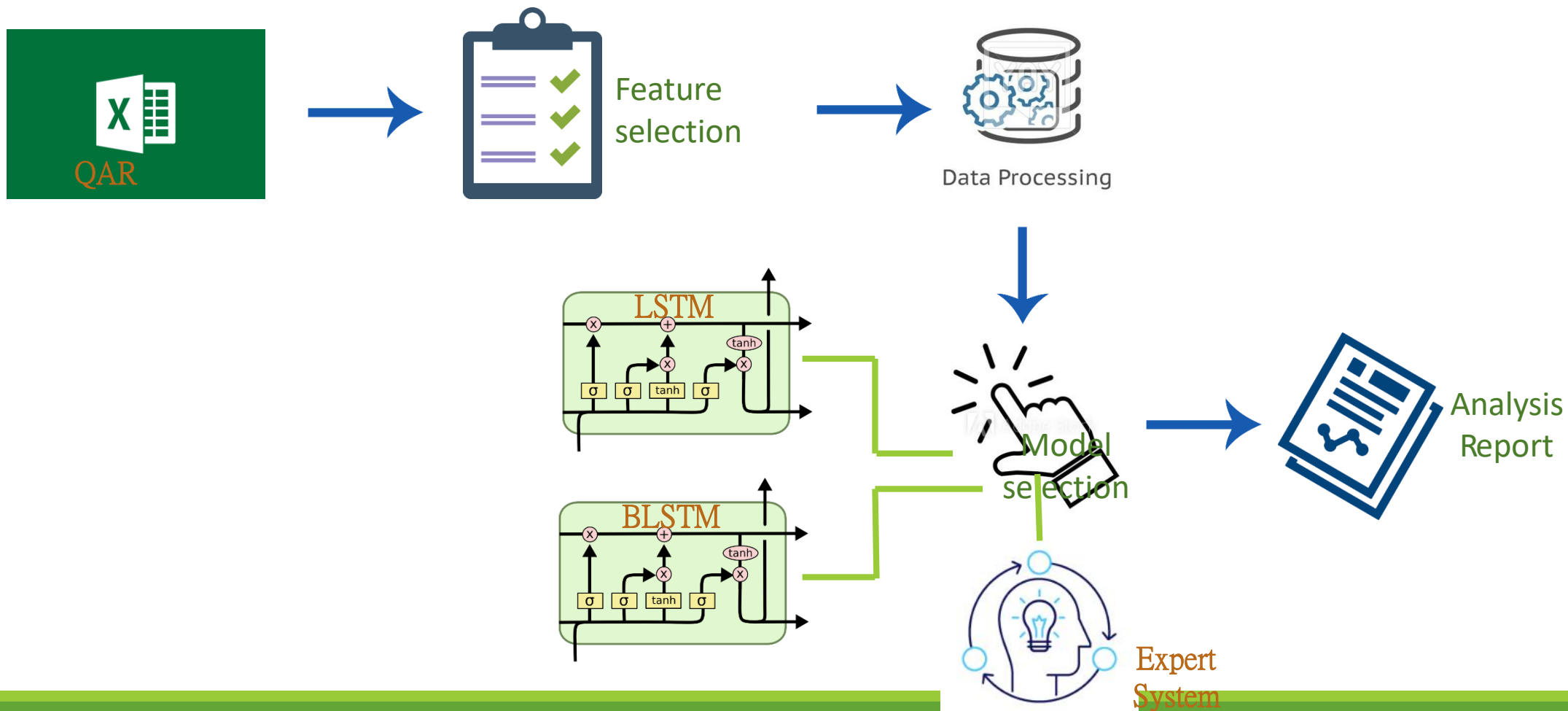
P: Improper flare attitude

T: Improper flare timing

L: Last moment input

The deep learning model BLSTM is able to produce almost good classification (80~90% is considered good)

The System



Conclusions

1. To make “Smart FOQA” is smart enough via continuing research and development by taking AI technologies and its applications.
2. This software tool on high G landing analysis will be available on Q2 2020, and will be shared with interesting parties.
3. A website will be built to provide system trial for users. Feedback from users are most welcome.
4. Beside the application of AI on casual analysis of respective FOQA event, the integration with FORAS data such as crew functionalities, aircraft functionalities, and sector threats for conducting more thorough analysis will be our next step.

Thank you

