Deep Learning for NAS

Real-time Hazard Precursor Identification

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Aviation Information World – Forecasting the Future
Deep Learning for NAS

- Big Data
- Data Science
- Big Data Analytics Trends
- Deep Learning Technique
- NAS Application
**NIST Big Data Reference Architecture**

*Big Data* consists of extensive datasets that require a scalable architecture for efficient storage, manipulation, and analysis.

https://www.nist.gov/el/cyber-physical-systems/big-data-pwg
Application Layer—Data Science

COLLECT

Need

Hypothesis

Capture

Explore

Organize

Analyse

Evaluate

Interpret

Explain

Deploy

CURATE

Contextualized Information

ANALYZE

Raw Data

Insight

Data Driven Decision-Making

Value

ACT

Models

Actionable Knowledge

Hypothesis Yields

Value

Insight

CollecT Curate Analyze Act
Why only 3 V’s

**COLLECT**
- Data Warehouse
- Volume
- Dynamic

**CURATE**
- ETL
- On-read
- Dynamic Integration
- Variety
- Velocity

**ANALYZE**
- Analyze
- Store

**ACT**
- Act
- Act

**Business Process**
- Collect
- Curate
- Analyze
- Act
Now: Internet of Things
Multi-tiered Architecture

Sensors | Fog/Local | Fabric/Regional | Data Lake/National

Yes, I'm a Mac fan-girl.
New: Compute vs. Data Intensive

- Shared
- Nothing
- Shared
- Everything
- New Territory
New Computing Trends

- Compute-intensive parallel computing
- Data-intensive parallel computing
- Data Centers and Data Lakes
- CPU and GPU
- Data Mining and Data Science
- Network for sharing vs. distributed computing
- Distributed Analytics
- Cloud and Micro-services
- Network Effect
Modeling Implication
Feature Extraction and Analysis

SELECT
CURATE
ANALYZE
ACT

Hypothesis

Data Driven Decision-Making

Insight

Value

Yields

Explore
Organize
Analyze
Evalue
Interpret
Explain
Deploy

Raw Data
Contextualized Information
Models
Actionable Knowledge
No-Feature-Extraction Analysis

Involves direct learning from data
Unsupervised for automated feature extraction
Combines supervised and unsupervised
Take a Cue From Neurobiology

Mimic the Brain
Deep Learning

This branch of machine learning is based on a set of algorithms that attempt to model high-level abstractions in data by using a deep graph with multiple processing layers.

- Since 1980
- GPU computing
- Distributed computing
- Distributed memory
- Large-scale storage

*Google's deep network that automatically created image filters for recognizing faces and cats.*
It's Not Your Father's Neural Network

Object Recognition

Object Classification

Language Translation

Anomaly Detection

Computer Vision
Deep Learning for NAS

Sensor Analytics
  – Failure prediction

Trajectory Analysis
  – Identification of hazard features
Component Failure Prediction

Sensor data from component
- Past data where failures have occurred
- Currently running data

Model learns from past data
- Features
- Relationships between features and fault classification
Component Failure Prediction
Deep Learning Use Case
Component Failure Prediction

System Monitoring

Data from past

Offline Data

Model Training

Deep Learning

Data Features

Prediction Model

Prediction

Failure

Non-Failure

Runtime Data

Current Data
Types of Deep Learning

From Neural Network Origins
– Torch, Theano, Caffe
– Supervised and/or unsupervised

From Neurological Origins
– Numenta Hierarchical Temporal Memory
– Continual Learning
NuPIC Approach
Numenta Platform for Intelligent Computing

Continuous online learning
Temporal and spatial patterns
Real-time streaming data
Prediction and modeling
Anomaly detection
Hierarchical temporal memory

Use Case: Trajectory Anomalies

Learning directly from observations
Neuroscience-based pattern recognition
- Learning, as the brain learns
- Good for pattern recognition

Continuous learning
- Not constrained to train-test-live
- Accommodates drift

Anomaly detection
- In space and time
Summary

Separation of model-building and model-scoring

Competition between data sharing and sharing analytics results

Alternate method for learning from data
  – Without feature extraction

Competition between physics-based models and unsupervised learning
Questions/Comments?

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