EEG CLOUD

Capstone Project

Supervisor: Phan Duy Hung

STARS RATED FOR EXCELLENCE 2012

FPT Fpt University

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Contents

Abstraction

- Exploring the feasibility of using a cloud-based approach to analyzing EEG signals

- Cloud-based benefits:
  - Allows us to leverage demanding analysis algorithms from mobile devices such as smart phones/tablets with limited resources and using these devices to stream data to cloud.

  - Have a much larger database to train the neural networks.

  - Opens up possibilities for statistical and analysis with big data.

Introduction

EEG collection devices become smaller and more mobile, so we need to perform EEG analysis on small-factor devices such as mobile phones or tablets

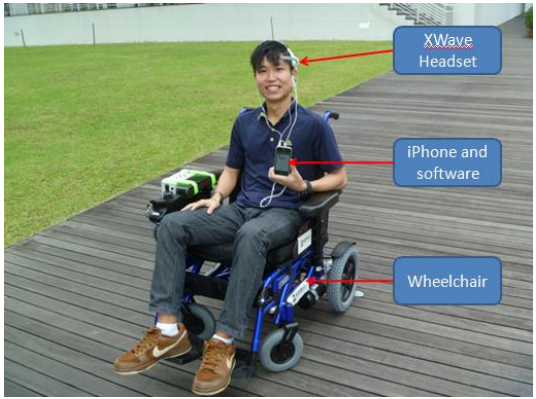
Android smart phones/tablets and Microsoft Azure cloud to transmit data, analysis and classifying brain's state intention and non-intention.

Introduction

Brain Computer Interfaces (BCI)

A brain–computer interface (BCI) is a direct communication pathway between the brain and an external device.

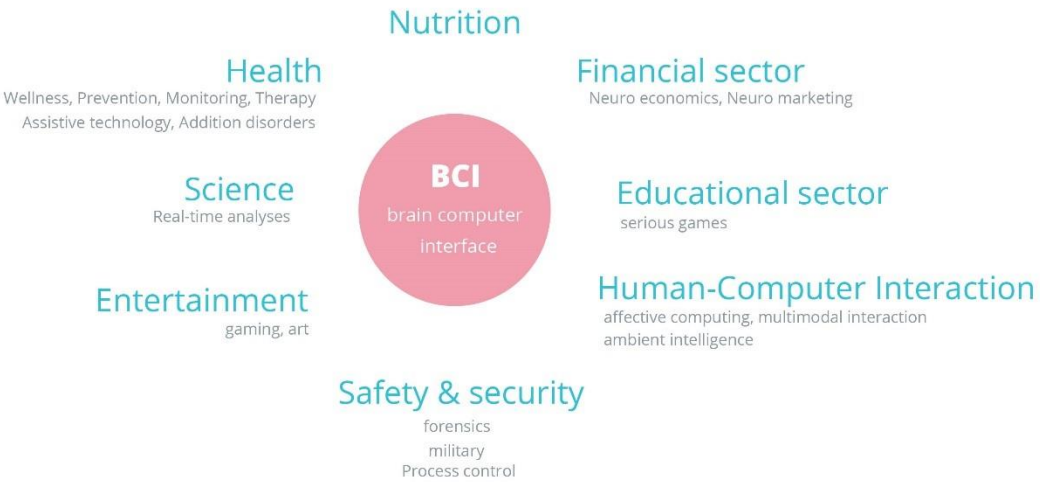
Brain Computer Interfaces (BCIs) had some achievements in recent years.



Introduction

Brain Computer Interfaces (BCI)

Application Areas of BCI



Introduction

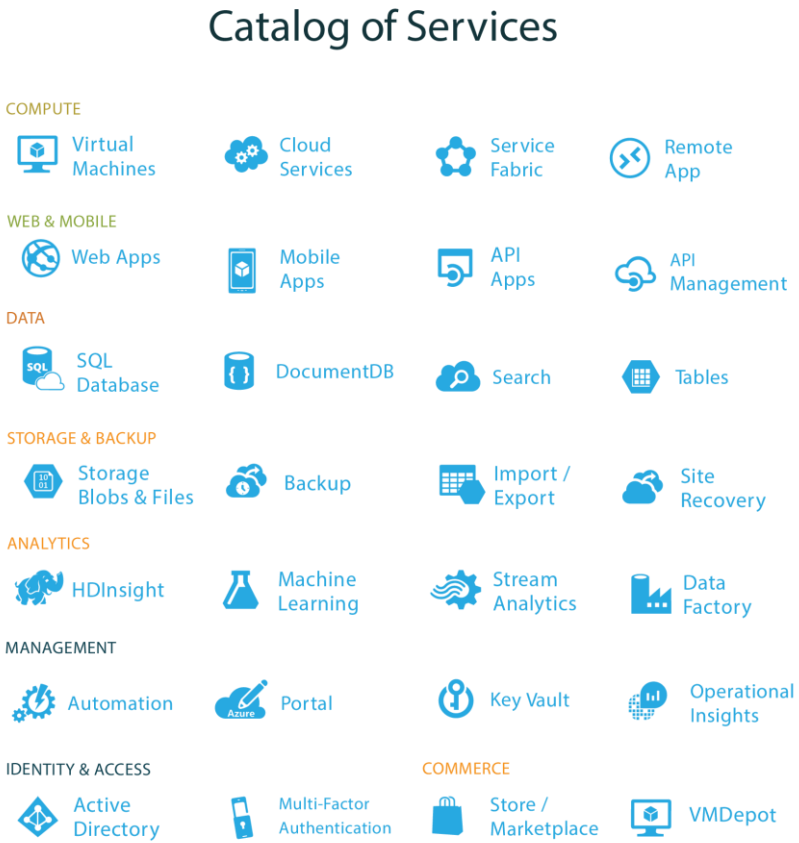
Microsoft Azure Cloud

Microsoft Azure is a cloud computing platform and infrastructure, created by Microsoft, for building, deploying and managing applications and services through a global network of Microsoft managed and Microsoft partner hosted datacenters.

Microsoft Azure is Microsoft's application platform for the public cloud.

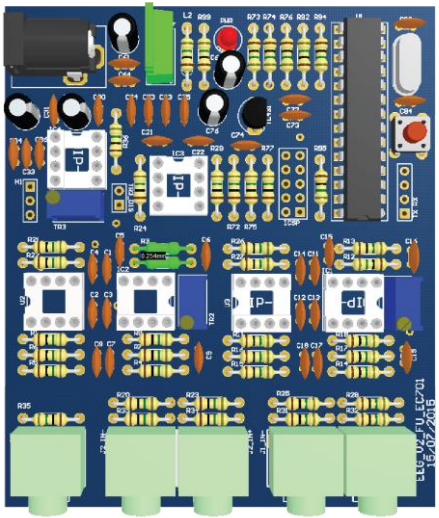
Introduction

Microsoft Azure Cloud



Introduction

EEG Device



Power: 9V (5V - USB connect)
Input: 1 DRL + 4 Electrode connectors
Output: via Bluetooth 2.0, 1 start bit, 8 data bits, 1 stop bit, no parity, 57600 bits per second.
Data package structure: 17 byte

```
uint8_t      sync0;      // = 0xA5  (decimal 165)
uint8_t      sync1;      // = 0x5A  (decimal 90)
uint8_t      version;    // = 2
uint8_t      count;      // packet counter. Increases by 1 each packet
uint16_t     data[6];    // 10-bit sample (= 0 - 1023) in big endian (Motorola) format
uint8_t      switches;   // =0
```

Sampling frequency: 256 Hz

CloudThink

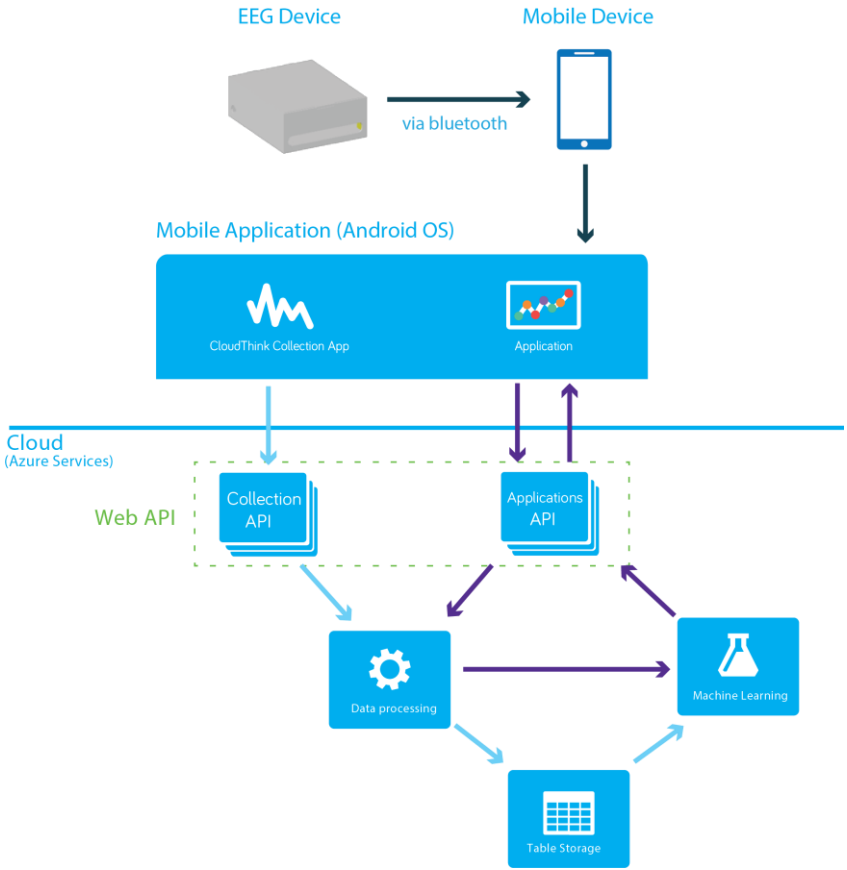
CloudThink is the product of this research topic. It is an integrated system including hardware and software.

CloudThink mix compute clouds and electroencephalograms (EEG) together. Using Cloud-Based Analysis of EEG Signals for BCI Applications.

We implemented the project in two phases:

1. Move the results of the “Electroencephalography Processing” project to Azure cloud.
2. Explore the Azure cloud capabilities to achieve desired results.

Overview


EEG Device
Mobile Device
via bluetooth
Mobile Application (Android OS)
CloudThink Collection App
Application
Cloud
(Azure Services)
Web API
Collection API
Applications API
Data processing
Machine Learning
Table Storage

Overview

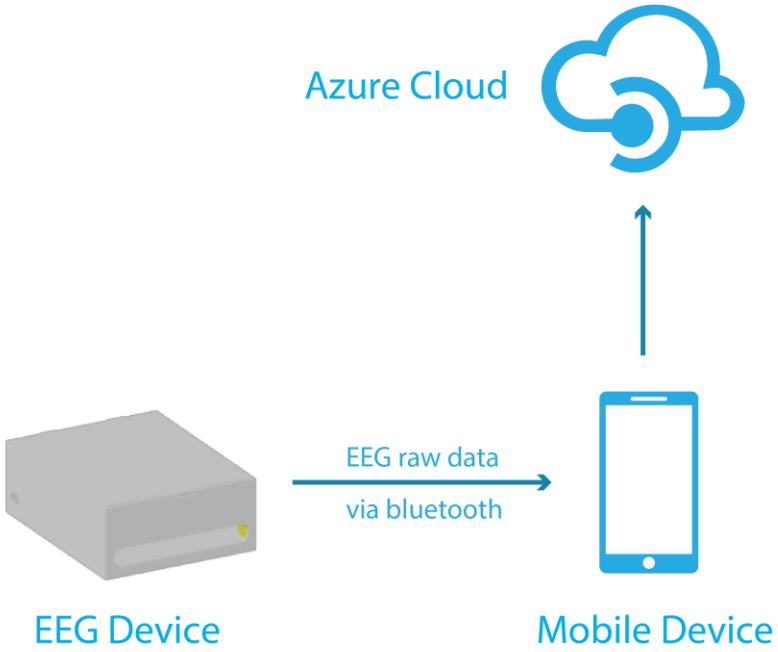
Main functions:

1. **Classification EEG data:** Gathering user's EEG data and create machine learning web service that allows classification EEG data to intention and non-intention.

2. **Applications using classification result:** Providing a platform for developers create applications using EEG data. Such as monitoring the brain health of an individual, playing game, ...

CloudThink App

Overview

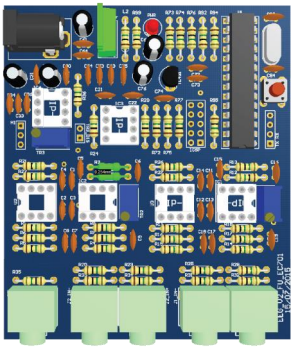


CloudThink App

Connect Bluetooth

response

connect

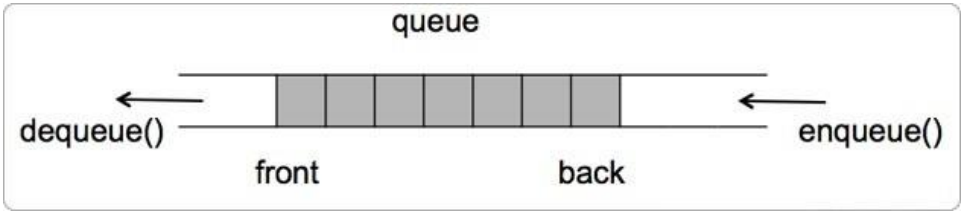


User information screen

Connect bluetooth

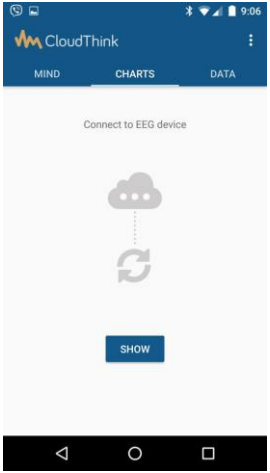
CloudThink App

Receive Data App

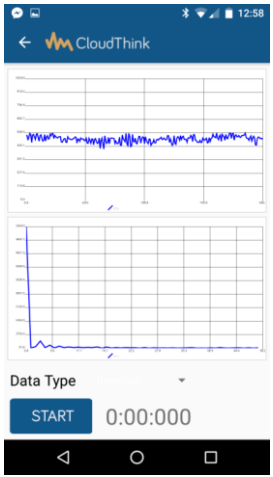


CloudThink App

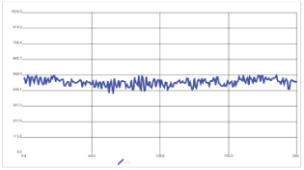
EEG Chart



Pre-EEG Chart Screen



EEG chart screen

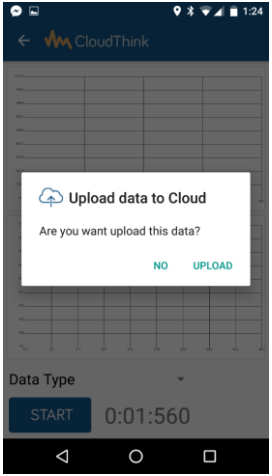


EEG raw chart

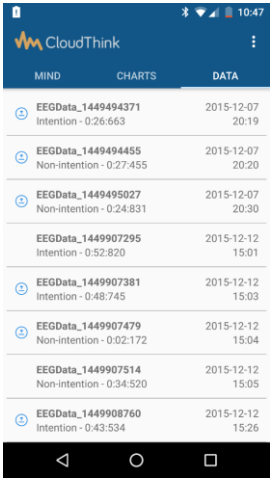
FFT chart

CloudThink App

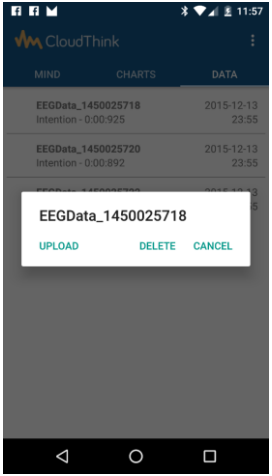
Upload data to cloud



Confirm Upload dialog



List saved data

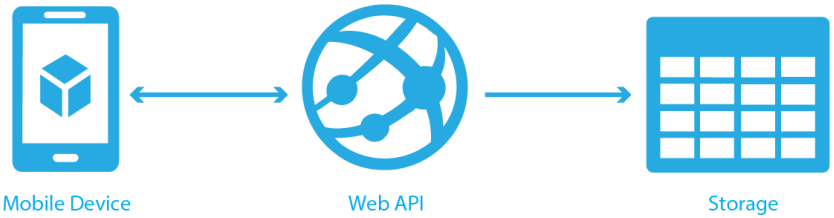


Action dialog

Web API

Web App

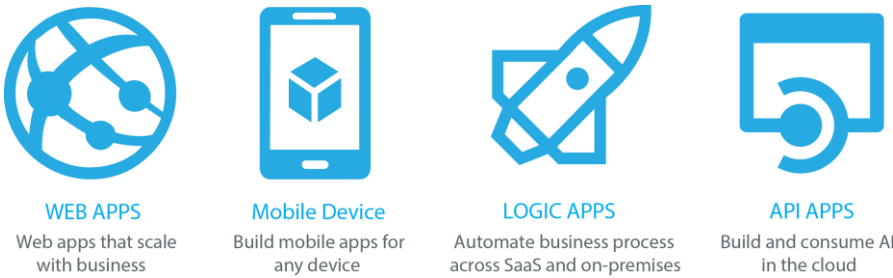
We using Web App in azure to create Web Api to connect Mobile app to Storage in Microsoft Azure.
Then we using machine leaning in Azure to lean data in Storage



Web API

API Apps

API Apps is one of four app types offered by Azure App Service.



CloudThink API

- Table storage easy to adapt your data as the needs of your application evolve
- Table storage is easy to use, so developers can create applications quickly
- Data queries faster and easier.
- It is non-SQL and suitable to store big data.

CloudThink API

Overview API App

Collect Data API

Application API

Analysis EEG Data

Analysis EEG data

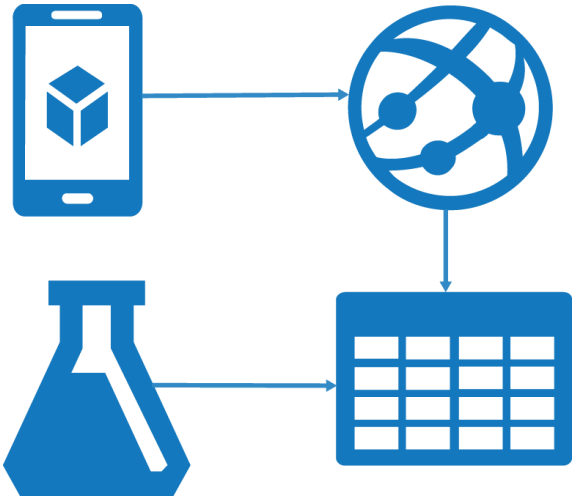
Analysis Data

Using characteristics inherit from previous projects group
Analyze EEG data to 9 characteristics

Features	Type
Percent Alpha	1x4 vector
Percent Beta	1x4 vector
Power Spectral Density Alpha	1x4 vector
Power Spectral Density Beta	1x4 vector
Mean of abs values of first different of normalized signals	a scalar
Mean of abs values of second different of normalized signals	a scalar
Skewness	a scalar
Kurtosis	a scalar
AR Burg	1x6 vector

Collection Data API

Receive raw data, split EEG data to segments in 2 seconds sample (512 samples) and overlap 16 samples. Extract features and storage in CloudThink table.



Collection Data API

Step 1: Push data on to Azure

- Mobile App use web API to push data onto the Azure
- Data is pushed up in the form Json
- data include name, age, gender and EEG data

Collection Data API

Step 2: Analyze EEG Data

Using Analysis EEG data to Analysis data is push up. Result is 9 characteristics

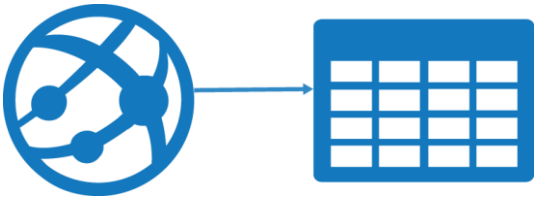
Collect Data API

Analysis EEG Data

Collection Data API

Step 3: Store data to Storage Table in Azure

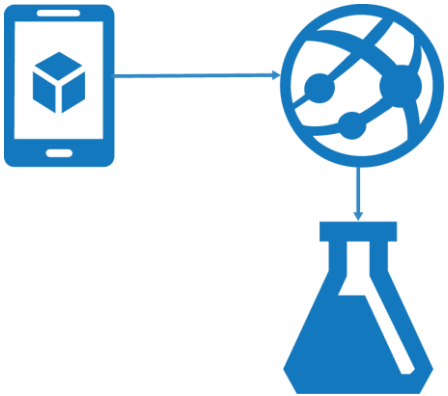
Using Analysis EEG data to Analysis data is push up. Result is 9 characteristics



- When we have 9 characteristics we store them on Storage Table in Azure .
- Data in Storage Table are used as training data for Machine Learning service.

Application API

Receive segment data (512 samples), extract features and call Machine Learning Web service to return classification result to client.



Application API

- When Machine Learning API is receive from Mobile
- Application , API will call web service in Machine learning.
- In Machine Learning EEG data will be analyze and then result
- Intention or Non-Intention to API
- When API have result , it will push result to mobile application
- Mobile Application can using result to play game

Machine Learning

Introduction

Machine learning explores the study and construction of algorithms that can learn from and make predictions on data. Such algorithms operate by building a model from example inputs in order to make data-driven predictions or decisions, rather than following strictly static program instructions.

Algorithms operate by building a model from example inputs in order to make data-driven predictions or decisions

Machine Learning

Machine learning type

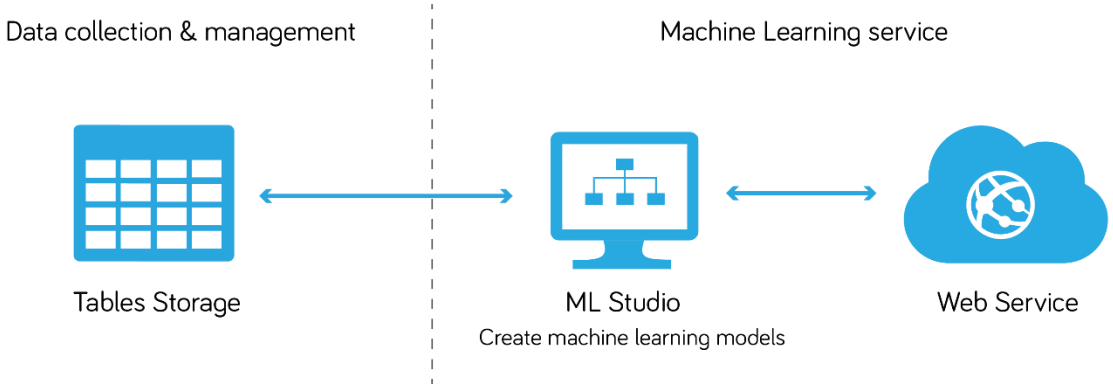
Supervised learning	Unsupervised learning	Reinforcement learning

Machine Learning

Initialize Model

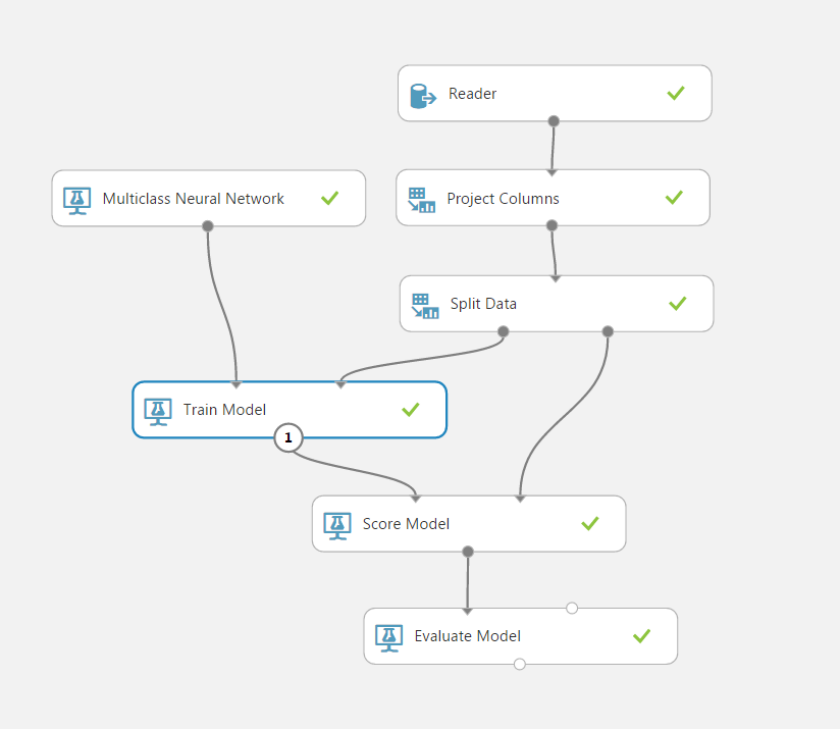
Azure Machine Learning

Workflow



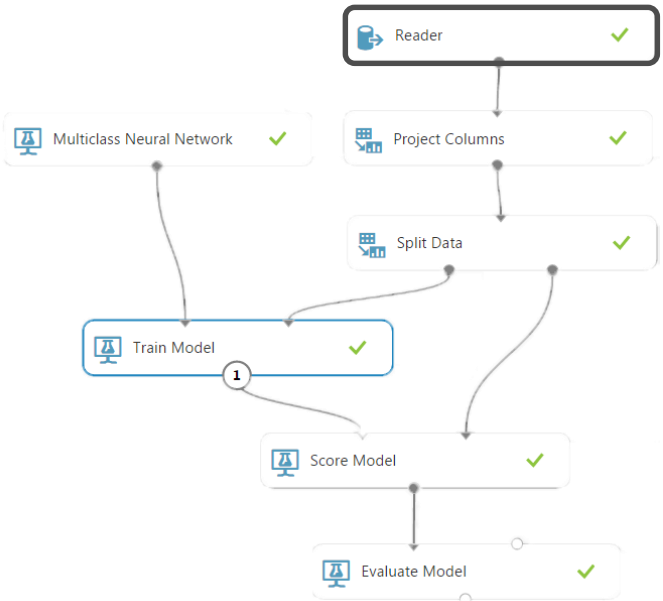
Azure Machine Learning

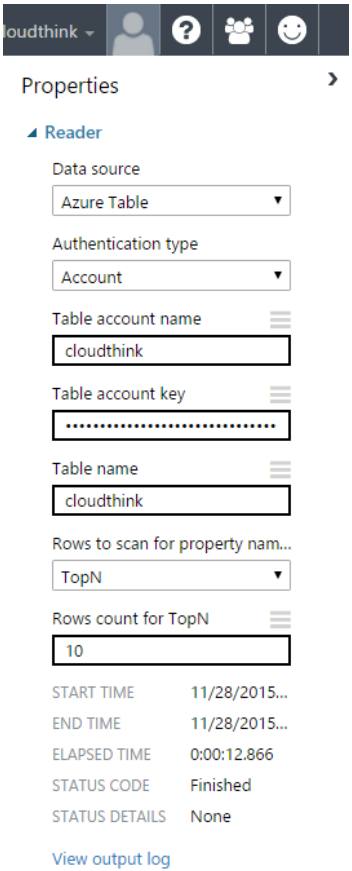
Training experiment



Azure Machine Learning

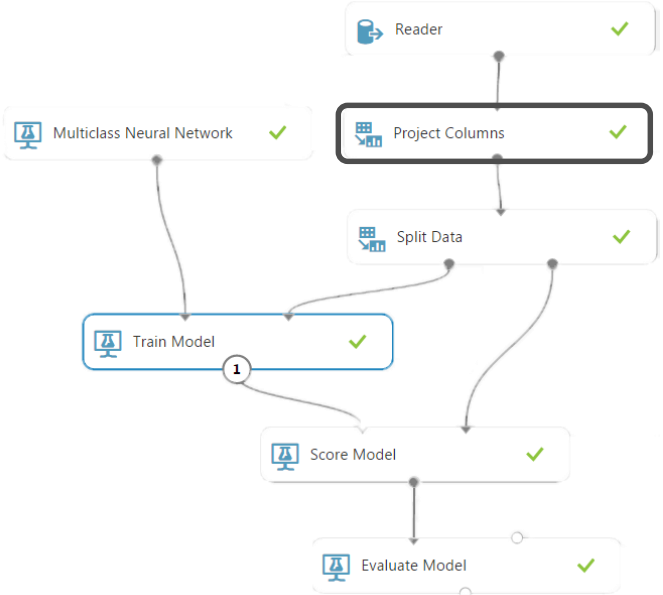
Get data

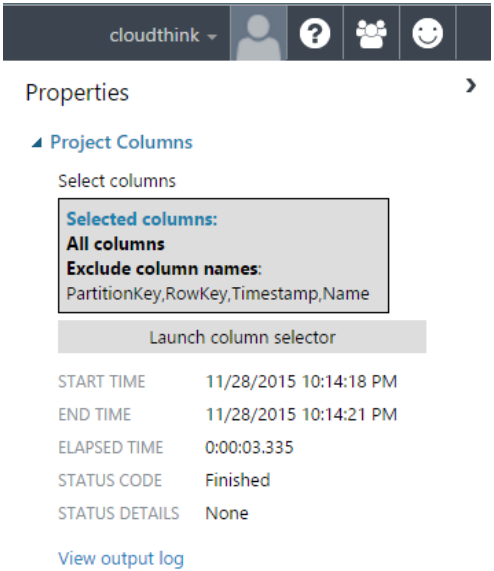




Azure Machine Learning

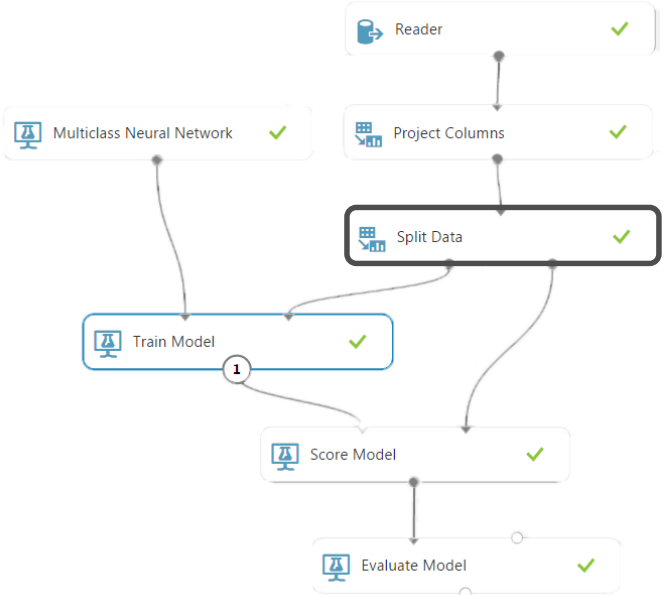
Pre-process data

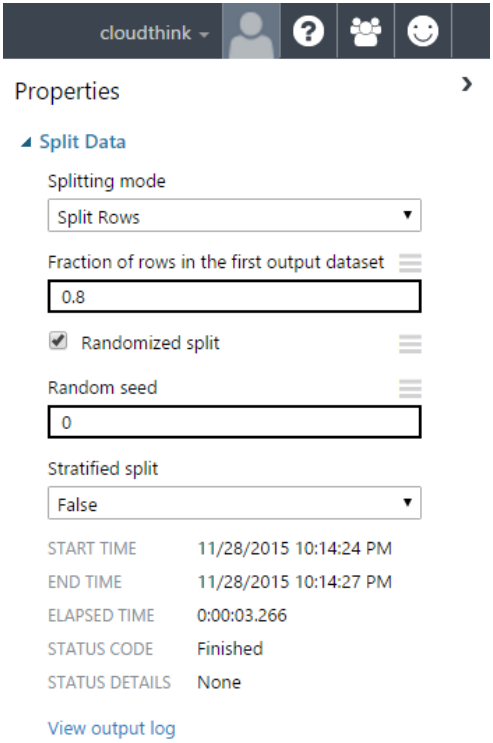




Azure Machine Learning

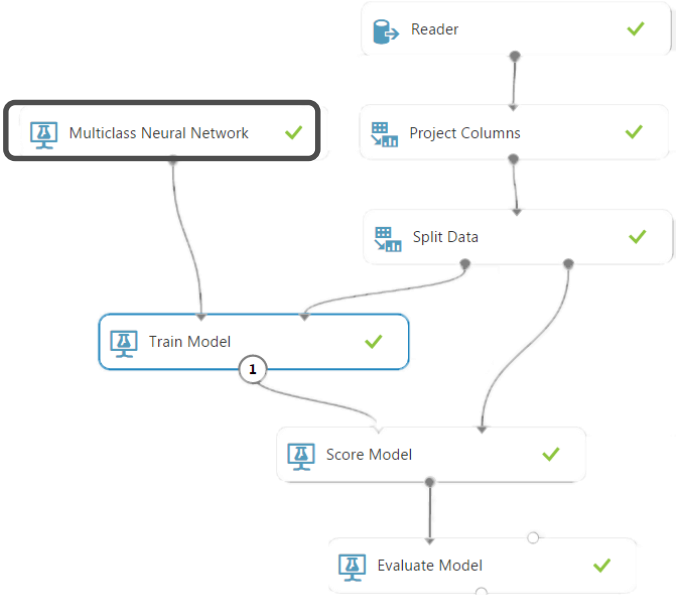
Split data

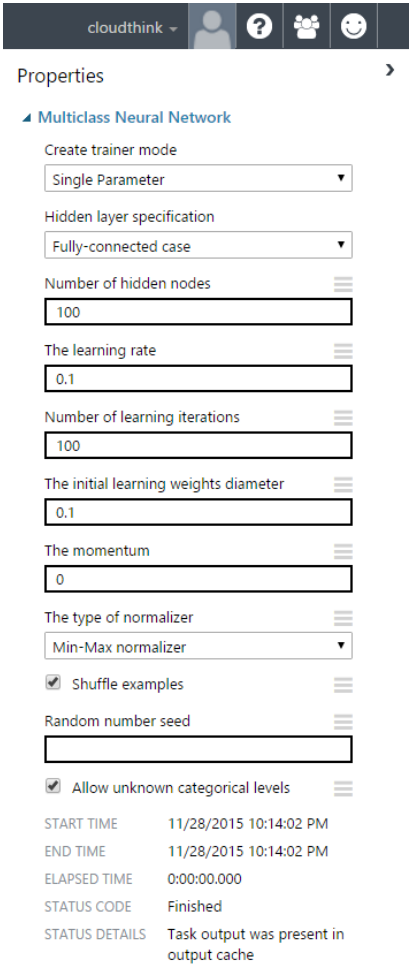




Azure Machine Learning

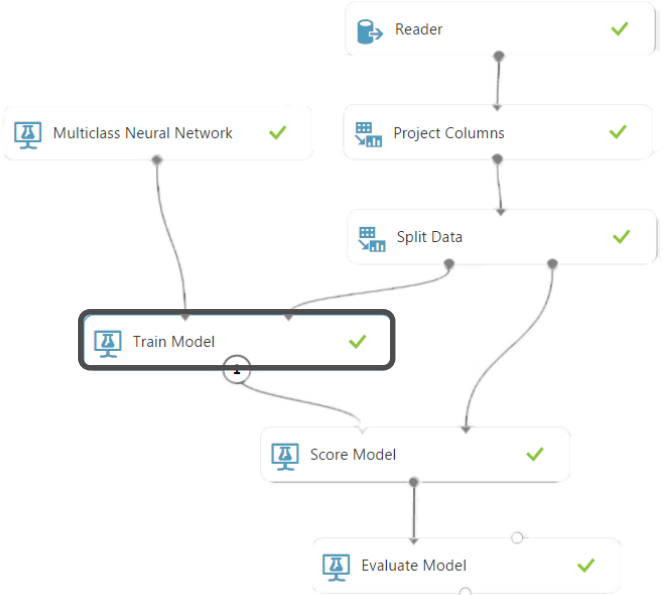
Apply a learning algorithm

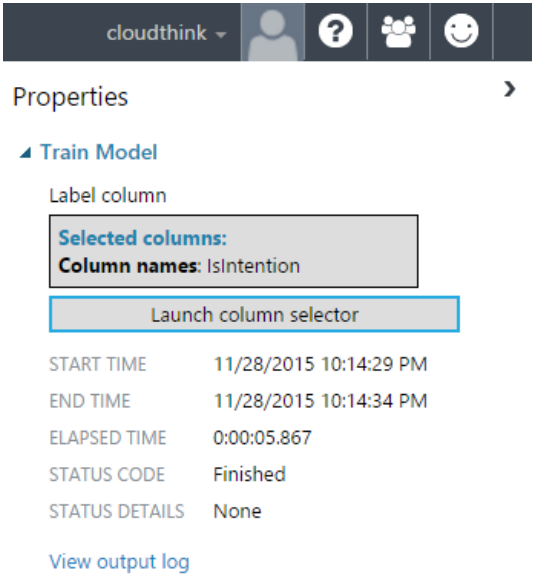




Azure Machine Learning

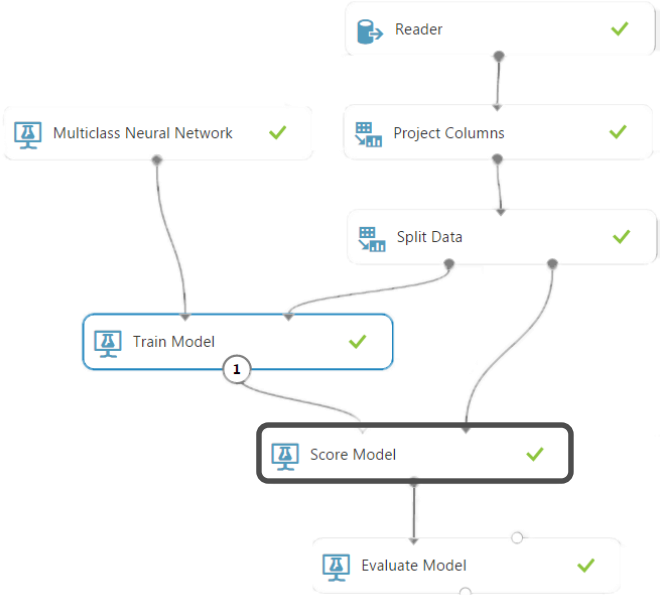
Train Model





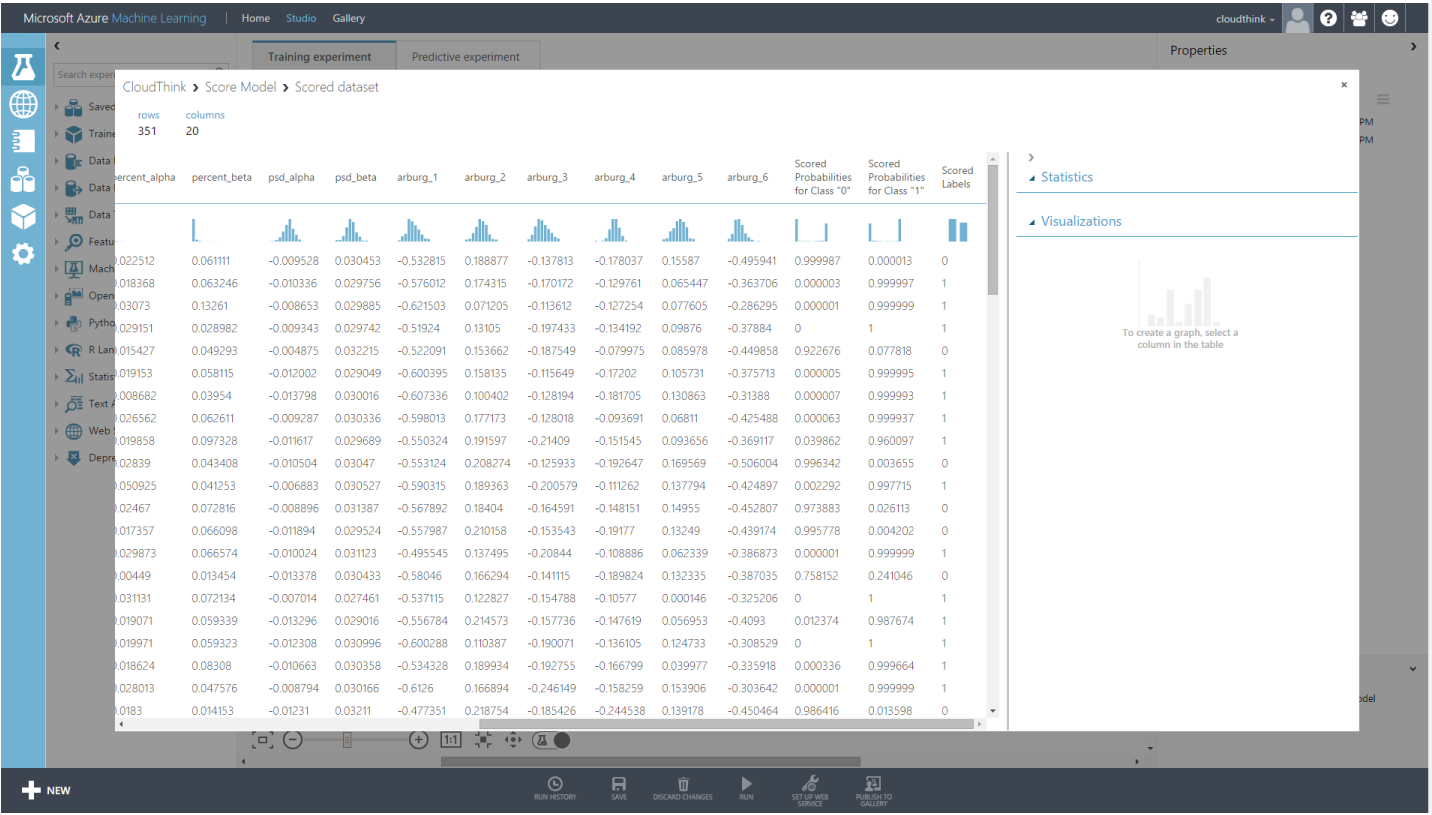
Azure Machine Learning

Evaluate result



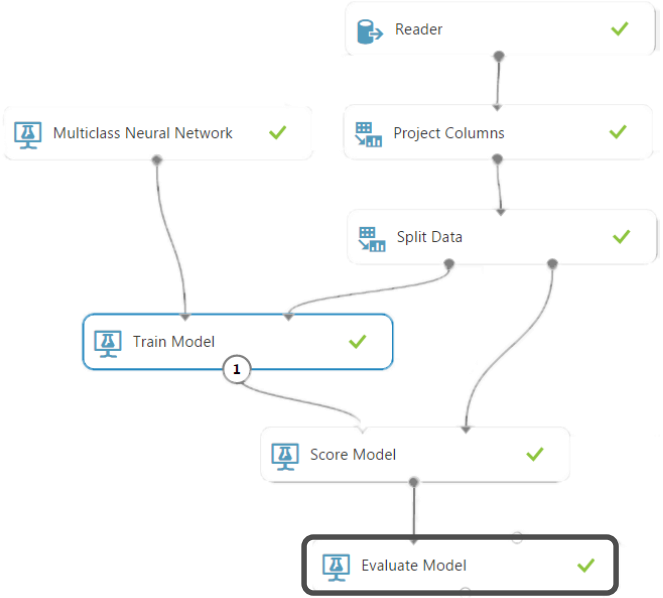
Azure Machine Learning

Evaluate result



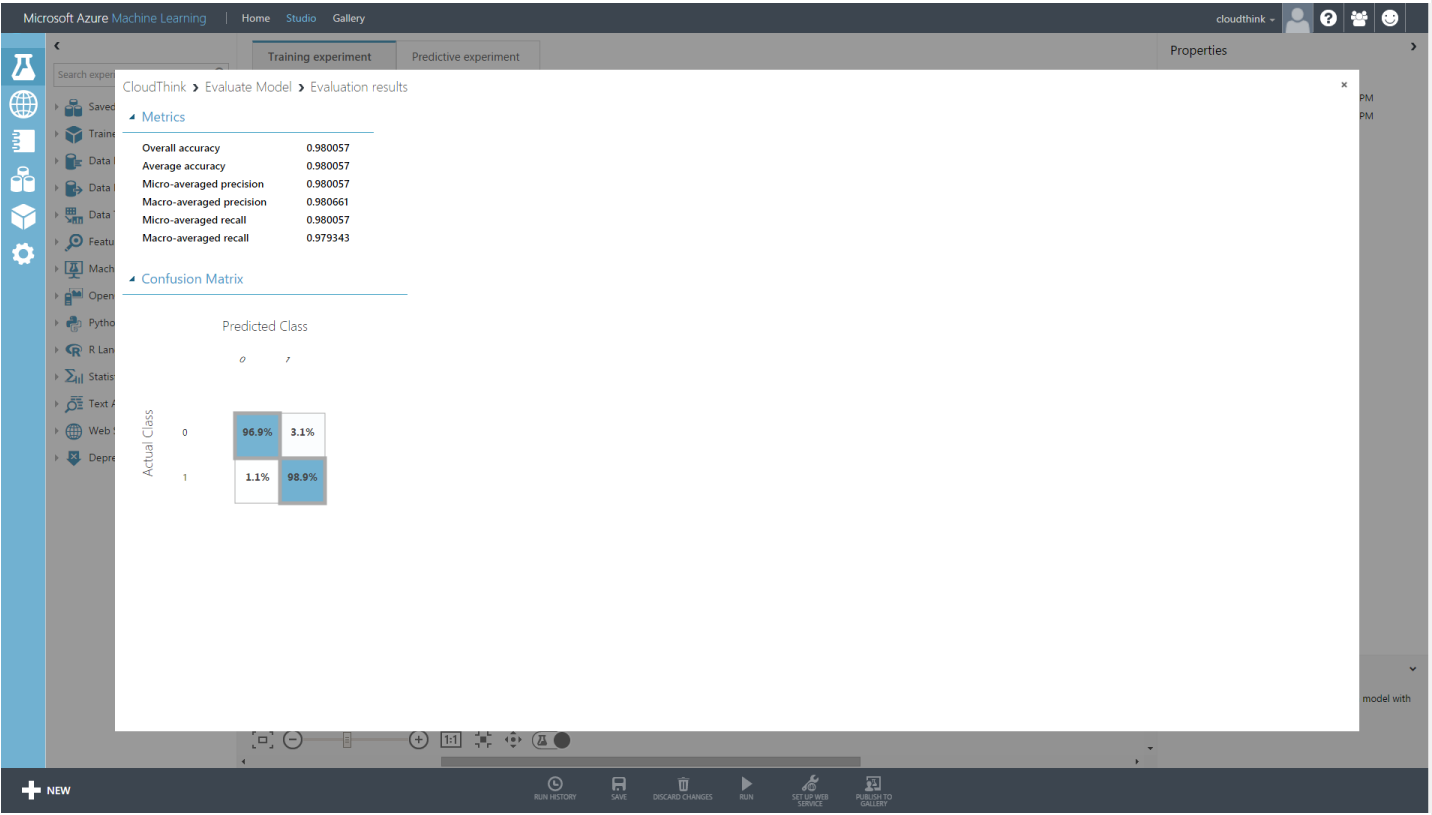
Azure Machine Learning

Evaluate result



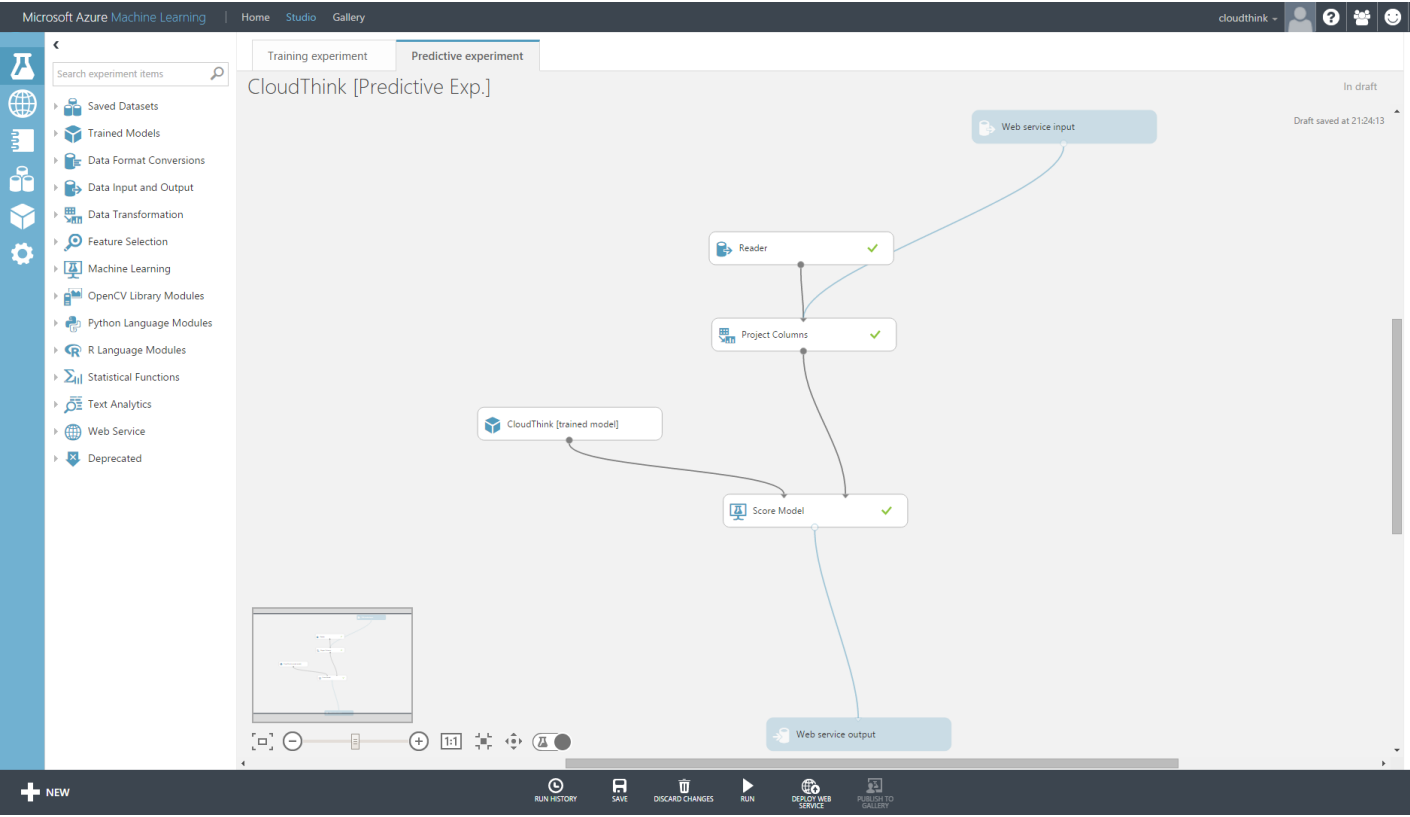
Azure Machine Learning

Evaluate result



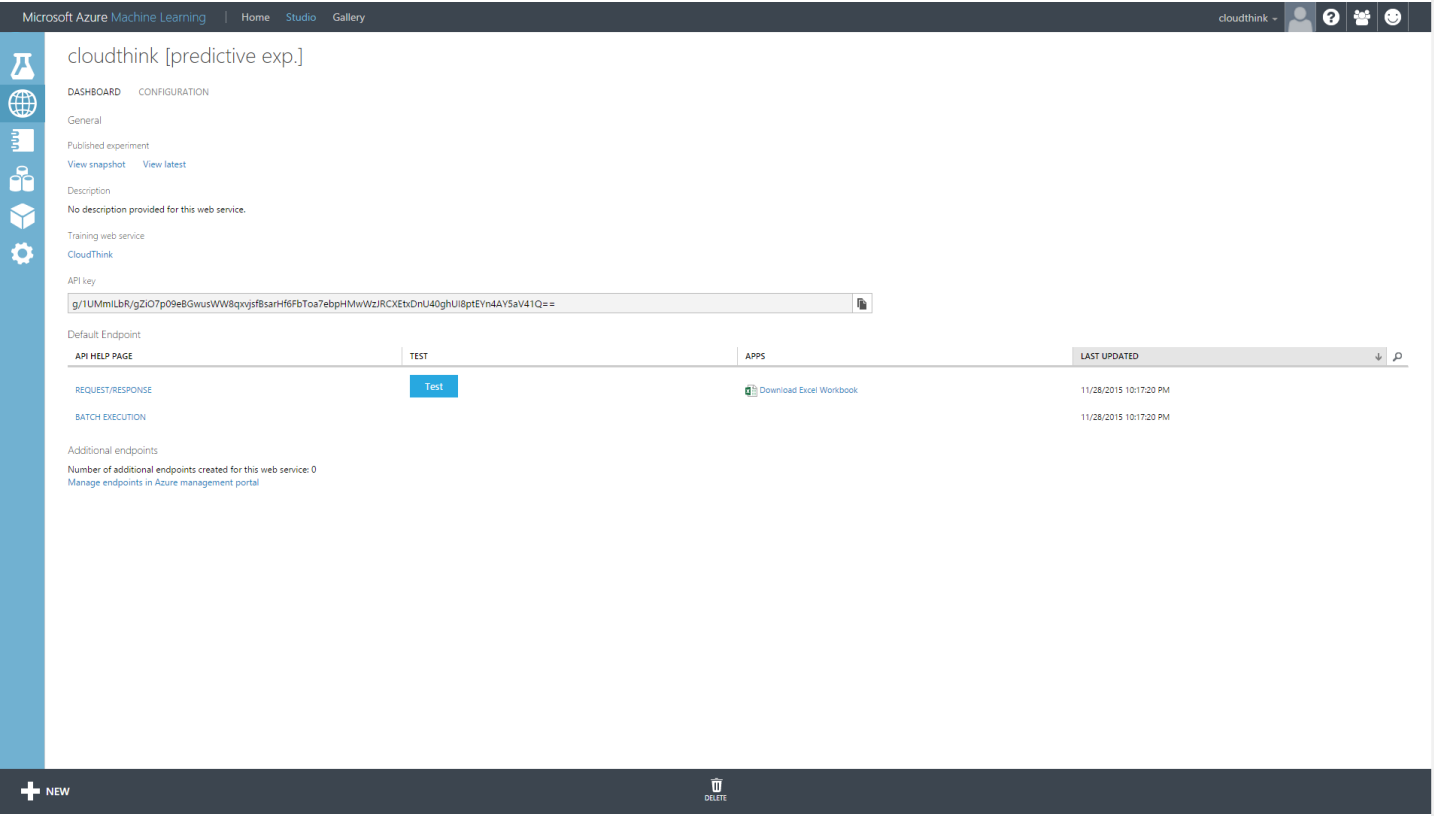
Machine Learning Web Service

Predictive experiment



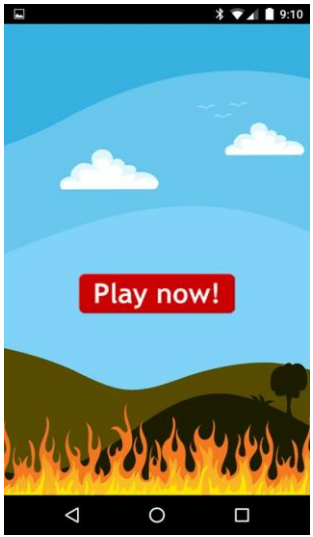
Machine Learning Web Service

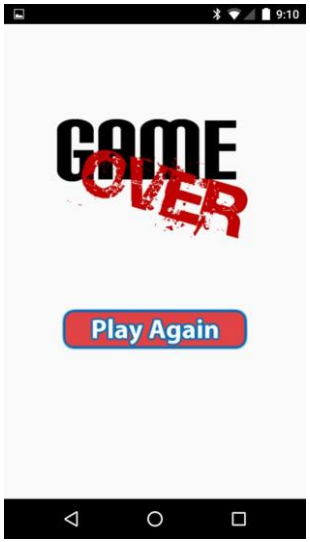
Web Service



Applications for EEG Headsets

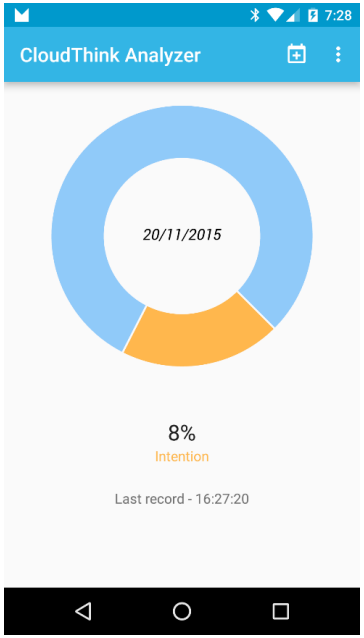
Game

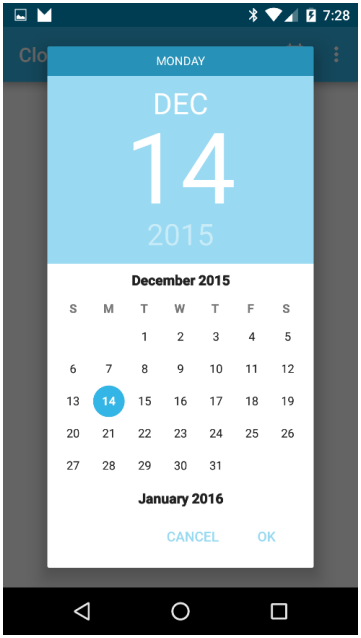




Applications for EEG Headsets

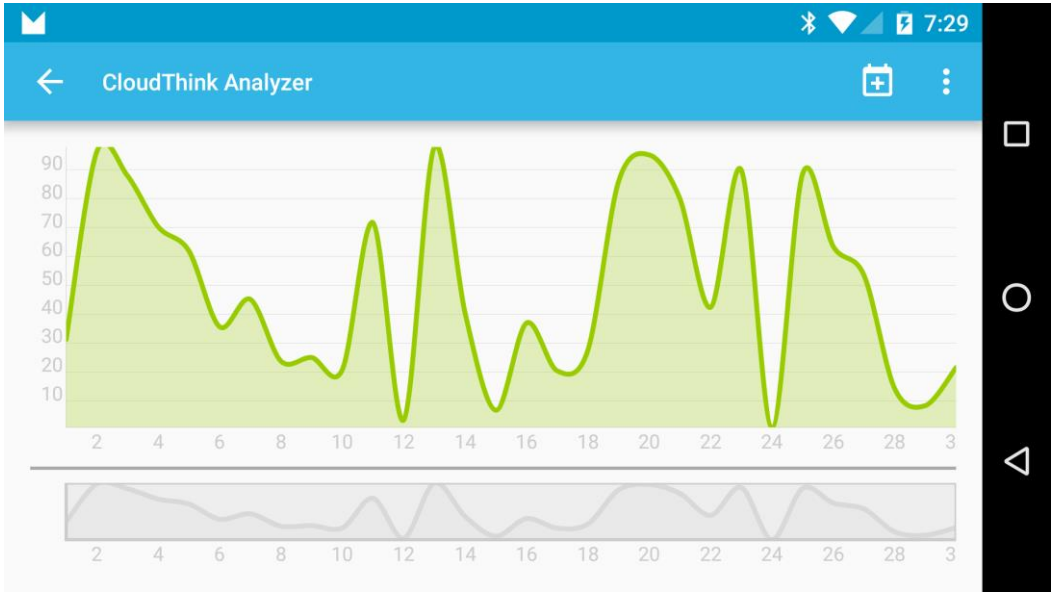
CloudThink Analytics Application





Applications for EEG Headsets

CloudThink Analytics Application



Result

Classification EEG data

Classification personal EEG data

Classification Multiple personality EEG data

Apply results of training

Playing real-time game

Result

Dataset:

- Collected from 1 women and 10 men aged around 22, healthy and right-handed.
- All of subjects are from FPT University and were informed the purpose of this experiment

Result

1. Classification personal EEG data

Name	Age	Gender	Classification result
AnhNPH	22	Male	1
TuanPA	22	Male	0.997061
HungNN	22	Male	1
ManhNB	22	Male	0.987551
LamNH	22	Male	0.993466
BacNV	22	Male	0.985646
DuongNT	22	Male	0.991244
ManhLN	22	Male	0.982345
AnhDD	22	Male	1
ChinhVC	22	Male	0.981564
HuyNM	22	Male	0.998546
MaiCTP	22	Female	0.976125

Result

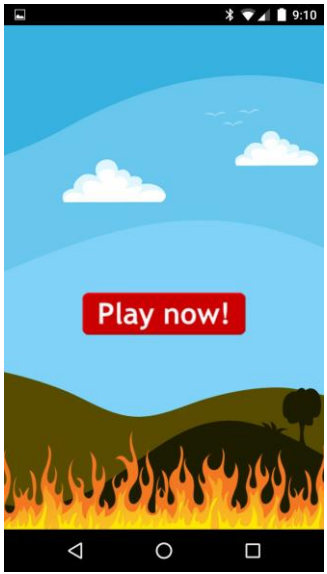
2. Classification Multiple personality EEG data

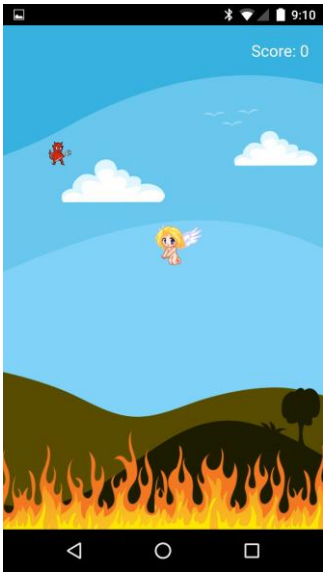
Test case	Result
2 persons (Male 2)	0.989243
5 persons (Male 5)	0.976512
11 persons (Male 10, Female 1)	0.969243
2 persons (Male 1, Female 1)	0.959243

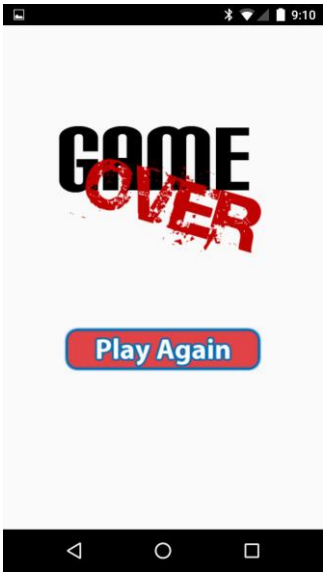
Result

Apply results of training

Play real-time game







Result

Play real-time game

Case 1: Play game with classification result of his/her EEG data

Case 2: Play game with classification result of multiple personality EEG data

Result

Play real-time game

User Experience Checklist

	Question	Answer
1	Have you played Save angle?	
2	Do you play any similar game ?	
3	Do you think this game would be suitable for you?	
4	What do you think about the difficulty of the game?	
5	Do characters move follow your desire or not?	
6	Are you satisfied with what you were able to achieve while playing the game?	
7	Do characters move quickly and smoothly?	
8	Will you continue to play this game beyond this test? Why or why not?	
9	If you had a magic wand, how would you improve this game?	

Result

Play real-time game

Case 1: Play game with classification result of his/her EEG data

- The majority of volunteers are satisfied with the game satisfied with the game.
- The player can control the characters move in subjective consciousness.

Case 2: Play game with classification result of multiple personality EEG data

- Players do not get stuck to control the character.
- The player can control the characters move in subjective consciousness similar playing game with classification result of his/her EEG data.
- We conducted experiments on volunteers is not in the database has been learned. Results playing game remains as expected.

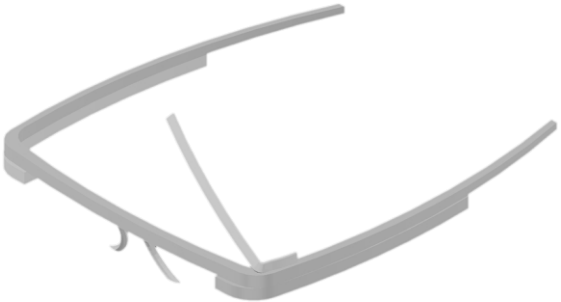
Discussion

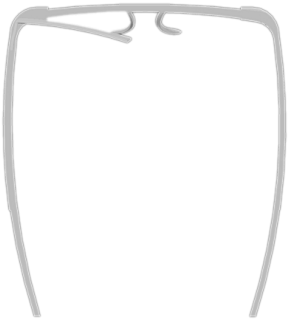
In the future, to achieve more accurate results, we need to conduct experience with longer duration, greater number of users.

We have explored methods of supporting multiple users concurrently.

Develop a small-form models, which allow quick classifications on the mobile device itself.

Future Work





The design described in this paper is the idea to carry a wearable headband that is easily connected to the smartphone, which acts as a medium to transfer data to the cloud network for analyses.

DEMO

Q&A