pathlon

be at your peak

SIOT - December Project

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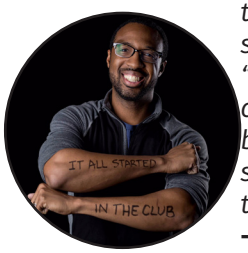
Introduction

Serverless architecture service system comprised of Alexa, AWS, Meteor weathere API, Fitbit API - actuated through Amazon Alexa.

With all available resource, online tutorials, flexible work schedules and devices to track health, people still experience the negative effects of being distracted, not being focused diminishing the impact of a individual workout session and overall mental/physical health. Knowing what time is optimal for you is key, and no consumer device as of yet can give you these personal impactful suggestions. Currently IoT is opening up new avenues for design and engineering, allowing us to create novel services that can allow the user to access a vast amount of data in form of actionable feedback . Personalised Healthcare, wearables, smart homes and personalised assistants are all topics driving the conversation . We are now seeing the personal tracking industry explore new ways to enhance health and wellbeing. This project aims to use your triathlon wearable data to inform best time of day to train → tracking sleep, amount of calories burnt, weight married with environmental data to determine in a given day what the best time of day is best to workout with the aim to prototype a commercially scalable service solution.

"I always am finding a way to hack my best performance for my body...one of the toughest oarts is to understand when my body is fully rested, fatigued and ready to train"
- Stefan (dutch Ironman)

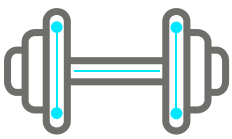


"I struggle to find the best time to workout, usually because I am so busy"
"I squeeze in an hour where I can, but mostly they end up not being effective, sometimes I am stressed after a meeting, or more tired after a busy day"
-Darian (Avid Sporter)

AIMS & OBJECTIVES

The objective is to design a data powered solution tracking peak athletic performance designed for triathletes.

MACHINE LEARNING



FITNESS

IOT

WEARABLE

DEVELOPING BRIEF / USER RESEARCH

01 Defining the Challenge. Identifying the scope of the IoT service solution.

SOURCING DATA 14-18 Dec

02 Identifying & self education on sensors, resources and infrastructure required.

LOGGING DATA 28 Dec - To Date

03 Logging real-time data from Fitbit device and local weather API.

BUILD MODEL 2 -5 Jan

04 Using data, compile a prediction model. Learn how to use AWS ML.

DATA ANALYSIS 2-5 Jan

05 Iterate data based on analysis. Includes cleaning data.

NOVEL INTERACTION DESIGN 14 Dec - To Date

06 1. Learn how to develop Alexa Skill
2. Implement prototype

SYSTEM ARCHITECTURE DESIGN 14 Dec - To Date

07 1. Learn how to implement AWS serverless architecture (incl. a database) 2. Implement

SIOT Project Timeline

1. ACQUIRING, STORING AND ANALYSING DATA

Defining Effective Workout

Biometric Data	• e.g. previous night sleep, heart rate
Activity Data	• Intensity e.g. active minutes (refer to Fitbit documentation METs, widely used method to calculate active minutes)

Factors Influencing Intesity

Sleep (lack of)

Time of Day

Environmental Conditions

Previous day's activity levels

Fitbit Flex 2 used for this project, as it satisfied the sensing criteria outlined above. Worn by Stefan for 1-2 weeks, collecting his workout data.

Sensor in Fitbit Flex 2:
3-axis accelerometer (movement into digital measurement, API intraday allows you to extract minute by minute steps) ; measures frequency, duration, intensity, patterns of movement to determine; distance traveled, calories burned, sleep quality. 'Unless you are driving in a car with a stiff transmission or on back country roads, your tracker should not give you credit for any work you don't do....you're device may register movements or restlessness as steps when you're wearing it while you sleep...and undercount...walking on a very soft surface such as a plush carpet' ; take this into account, therefore relied on time-stamps and activity level threshold to be at the maximum to control the amount of error in later using the data to create a model. Taking this into consideration, this further is in line with Triathlon athletes requiring information and feedback on their peak performance rather than moderate activity.

Inputs & Storage

fitbit {api} METEOSERVER {api} DATABASE

TYPE OF ACTIVITY	VERY ACTIVE MINUTES	AVERAGE TEMPERATURE
TIME OF THE DAY	NUMBER OF MINUTES SLEEP	RELATIVE HUMIDITY
ACTIVE CALORIES BURNED PREV DAY		WINDSPEED

→

Code and data collected can be found through github link https://github.com/Kvdf/SI-OT-DE4-Optimisation---Pathlon

Target & Challenges Identified

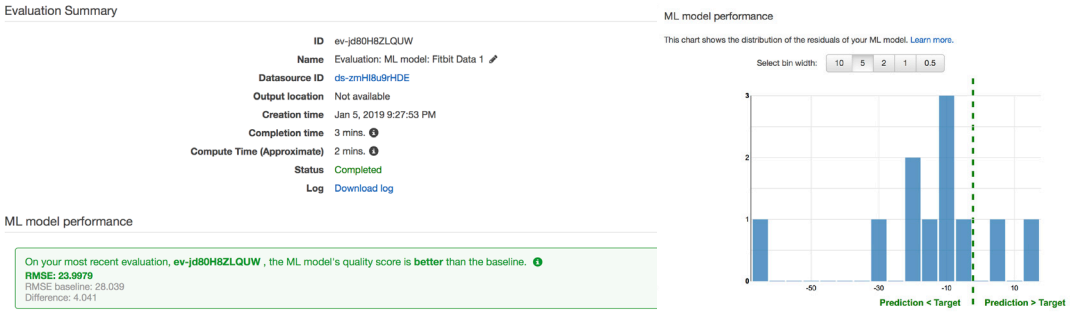
Predicted time of day for optimal workout session. Relying on Fitbit MET (metabolic equivalent given between level 1-3) algorithm to calculate activity intensity and therefore data collection is limited, however it has been a industry-wide accepted method. Intraday data, such as heart rate (not possible to measure on current Flex 2 model used for this prototype) would be a more reliable way to apply your own algorithm on.

Time Series Analysis

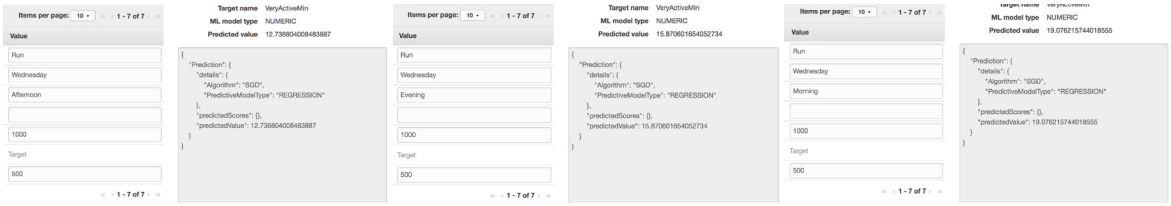
Linear regression was chosen as the aim was to find a numerical prediction. An important criteria in choosing to use a service to create models over coding our own, was the aim to integrate the machine learning model into the prototype serverless architecture service using AWS. Their built in linear regression algorithm is a widely used and trusted industry standard RMSE (root mean square) metric, therefore we ensure a level of quality in our model creation.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N} (Predicted_i - Actual_i)^2}{N}}$$

Interpreting this, in order to determine whether our fitbit model would allow us to make accurate predictions, the model was iterated to reduce the RMSE value as close to zero as possible. A final RMSE value of 23.979 was achieved, better than the mean prediction of 28.039 for the input parameters.



Additional, reviewing the the amount of target area the model cannot predict, the aim was to find a model that would balance the positive and negative residuals either underestimating or overestimating our target value. In this review stage, it was made sure that there was not potential structure in our model's error, making sure the histogram was bell shaped and centered around the zero. In our model, we did not achieve a zero-centered histogram, therefore to improve this model we will require, upon validation, that our users can expect more accurate recommendations after at least 2-months worth of data (comparing to our current 1-2 week data set), to ensure that their prediction model will make random errors instead of structured errors negatively affecting this current model's accuracy.



Before deploying and coding real-time predictions in our serverless architecture, prototyping real-time predictions was conducted. AWS real-time prediction GUI, was a useful tool in this stage of the design process. It was possible to simulate the fitbit API data that would be feeding into the prediction model and give us our target prediction.

For this simulation, the target was to find which time of day would affect the 'Very Active Minutes' prediction, similar to our aim for the overall Pathlon service to be achieved. By identifying the highest value prediction (i.e. time of day where we can achieve the most 'Very Active Minutes'), we were able to immediately see desired results. The prototype simulation exercise, showed that the optimal time to workout was in the 'Morning', with a prediction value of 19.07 compared to 12.7 and 15.8 for 'Afternoon' and 'Evening' based on the model and its most recent input data. See Section 2 how this was automated and integrated into the service system.

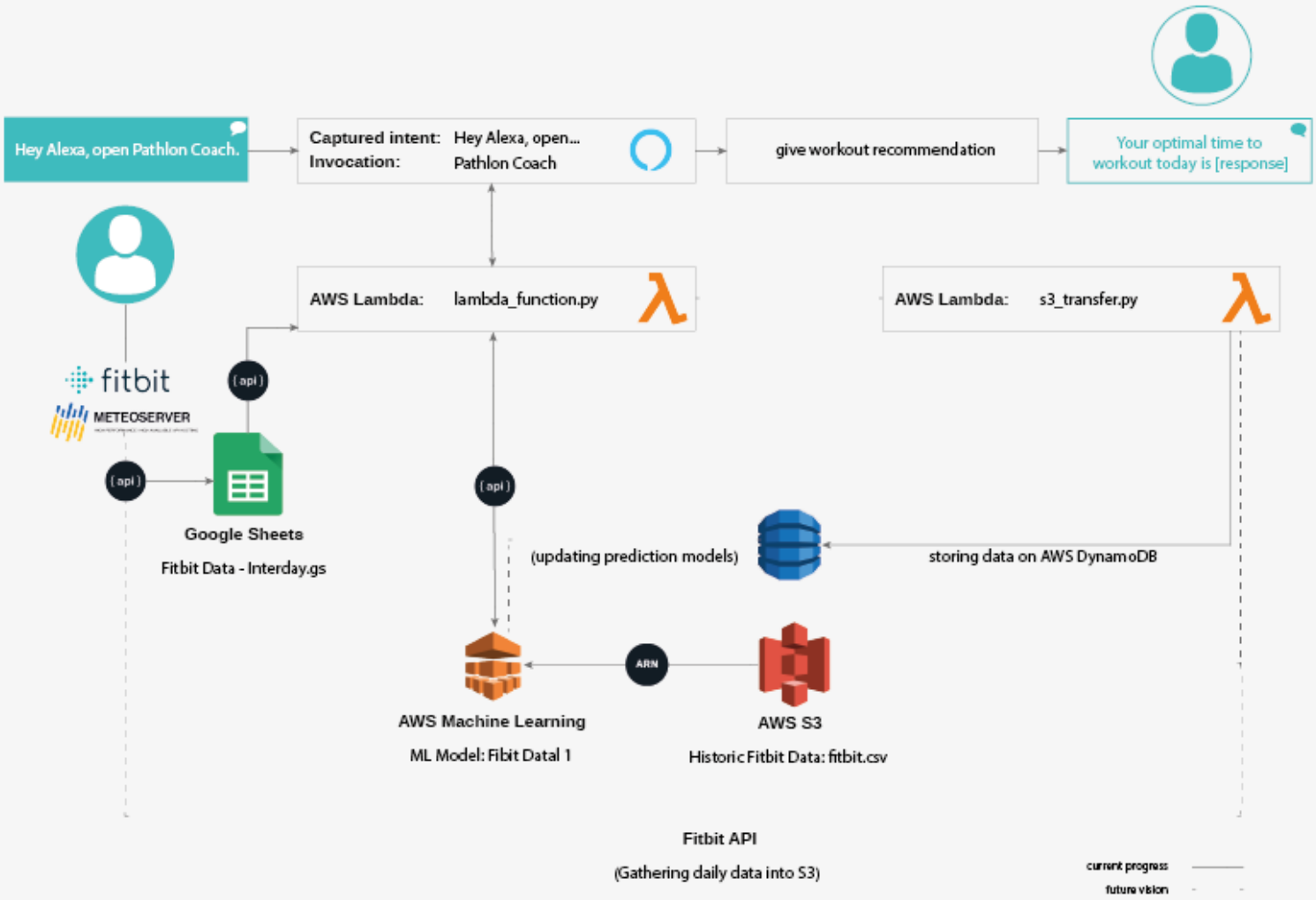
2. DESIGN, DEVELOPMENT AND DELIVERY

End-to-End Service

To achieve a fully serverless cloud-hosted architecture hosted by AWS, the following building blocks were compiled;

AWS lambda (event triggered Functions as a Service (FaaS) platform, responding to HTTPS requests through APIs), Auth02 (third party authentication service),AWS Machine Learning, AWS S3 storing (cloud accessible database), Alexa Skill (acting as a event trigger, user-driven query). Fitbit Flex 2 communicates to the Fitbit App via bluetooth, and therefore when user syncs his data through the App to see his Fitbit stats, the Google Script is triggered to automatically sync daily to retrieve this latest data.

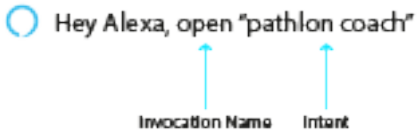
See below a flow diagram of these building blocks compiled;



Above you can see the elements building towards a full serverless architecture, shown the elements that have been achieved and work-in-progress/prototype components such as transitioning away from Google Sheets to DynamoDB to host prediction models. Furthermore, the aim is to implement the authentication service achieved in Google Sheets into AWS lambda in order to open the service to any potential customer, as well as continuously reading and storing Fitbit data to the cloud-database (in order to iterate prediction models).

VUI (Voice User Interface) Design

Upon interviewing and gaining insights from triathletes and semi-professional athletes, it was clear that their morning routines would differ. Either spending long hours commuting to work, or waking up early to train. In all instances, it was clear they had limited time in the morning and usually had a routine. Allowing a VUI (Voice User Interface) to be accessed hands-free and location-free to an extent within your home through an Alexa enabled device, aims to not obstruct their morning routines and responsibilities. The strength of Pathlon Coach VUI is blending into the background; aims to improve user satisfaction while being direct and simplistic in its interaction.



Learnings & Challenges Identified

When deciding a third-party FaaS platform, Google was considered due to user-accessibility advantages. Storing data to a google-sheet is intuitive for and usefull to monitor the data stream coming in. However, it was decided to use Alexa as the user interface, and therefore AWS was sought out to set up the preliminary FaaS. This came with a learning barrier, however Python was supported in the function virtual environment and therefore soley demanded how to integrate code, IAM policies , Roles, triggers and API requests into the AWS ecosystem. The scope is promising, as the platform is cloud-based and scales easily, and supports a database, API gateways, logging capabilities.

FUTURE DEVELOPMENT

01

Accuracy of Data Collection

Increase accuracy of data collected; upgrade Fitbit/ Wearable equipped with heart rate sensor; this directly increases accuracy of Active Calories Burned. Consideration needed to be taken; sampling rate of a fitbit heart rate sensor (using light) is 5 seconds. Adding to this, integrate an IoT weighing scale (e.g. Fitbit integrates their weigh scale product into their customer platform Dashboard), that can update your weight variable in real-time (daily) without requiring daily user-input.

02

End-to-End Service

Real-time automation, migrate everything to run solely on AWS. Future vision is identified in the flow diagram; transitioning from Google Sheets to DynamoDB, migrating the ‘Client Authentication’ code in .gs to AWS Lambda function.

03

User-Experience

Add token verification process into Alexa Skill rather than Google Sheet; so that data used is from their own individual Fitbit device. Updating the model, to automate adding more historical data to the ml model (monthly) improving the workout recommendation. Developing recommendations for each activity as well as designing user-dialogues for the Alexa Skill.

3. REFERENCE MATERIAL & RESOURCES

Use Final Solution

Prerequisites;

1. Alexa Enabled Device/Alexa Mobile App (Free), Create an Amazon account

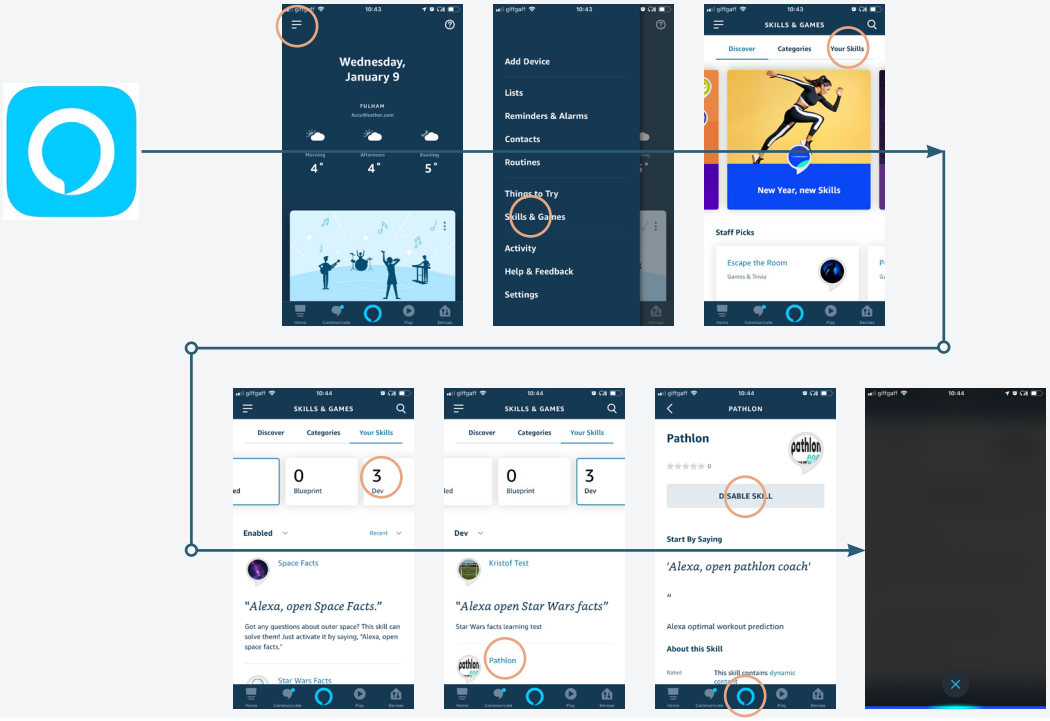
Alexa iOS app - https://itunes.apple.com/dm/app/amazon-alexa/id944011620?mt=8

Alexa Android app -https://play.google.com/store/apps/details?id=com.amazon.dee.app&hl=en_GB

2. Providing your email address (linked to your Amazon account) to receive a 'beta' version.

m: kev15@ic.ac.uk. Subject: Fitbit SIOT Project and request a 'beta' version.

Open Alexa App - Login - Set up - Select Tabs - Skills & Games - Your Skills - Dev - Search for Pathlon in Dev - Select - Enable Skill - Click Alexa Speech Bubble Icon - ask ; "*Alexa, open pathlon coach*"



AWS Documentation https://docs.aws.amazon.com/index.html#lang/en_us

Alexa Skill Kit https://developer.amazon.com/alexa-skills-kit

Fitbit Developer Documentation https://dev.fitbit.com/build/reference/

Fitbit Sensor information https://help.fitbit.com/articles/en_US/Help_article/1141

Code https://github.com/Kvdf/DE4-SIOT-Pathlon

Supporting Video https://www.youtube.com/watch?v=aX9-Ffasndk