Final Presentation:
HealthBuzz
A health reminder

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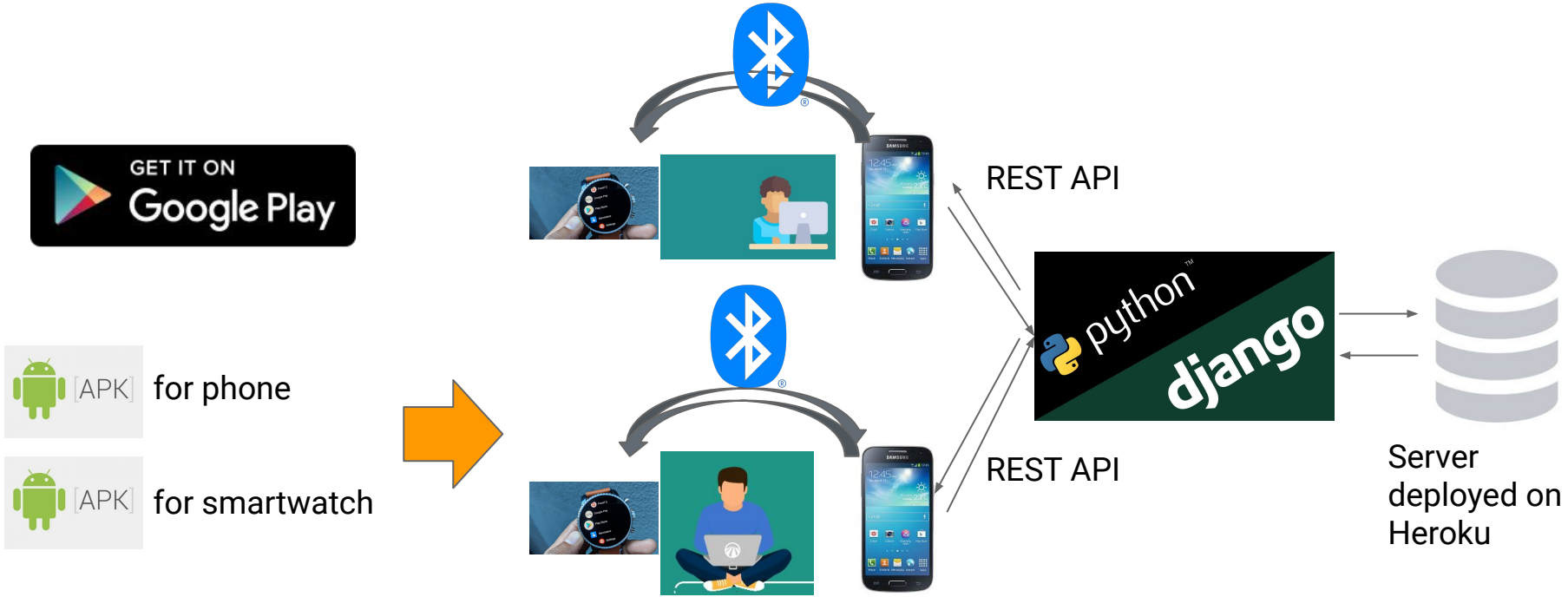
Quick recap on the project

- **Motivation**
  - People who sit in front of their desk for long time need reminder to stretch (customized interval)
  - People who forget to drink enough water for health(8 cups)
- **Proposed Idea**
  - By using sensor data, we build model to detect cup grabbing and inactive state and remind user automatically to drink water
- **Novelty**
  - We provide different service by checking user's smartwatch availability
  - We alarm user to drink water at appropriate time using ML.
  - We recommend YouTube videos based on the detected state (Stretch for sitting, Cool down, Running)

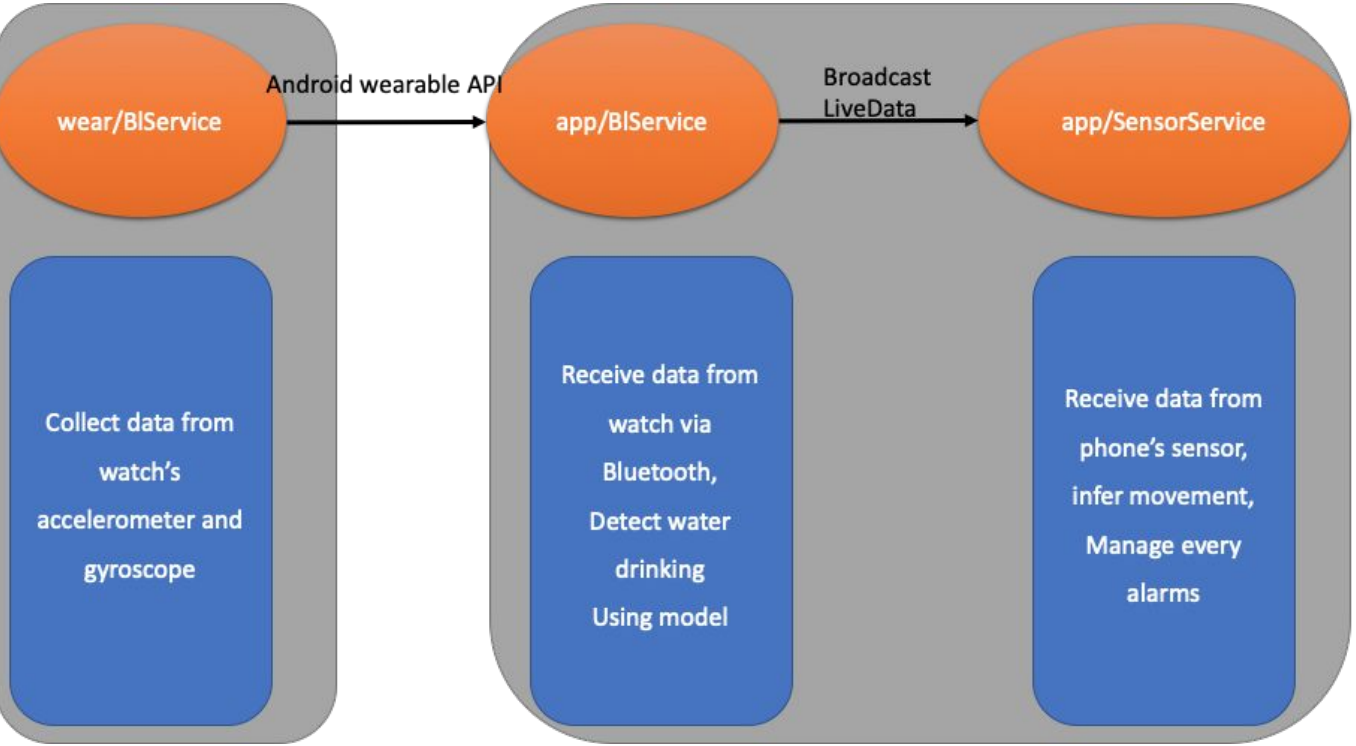
Demonstration

Login -> go to detail, and show stretching, water drinking motion

Health Buzz's overall architecture



Health Buzz's overall architecture

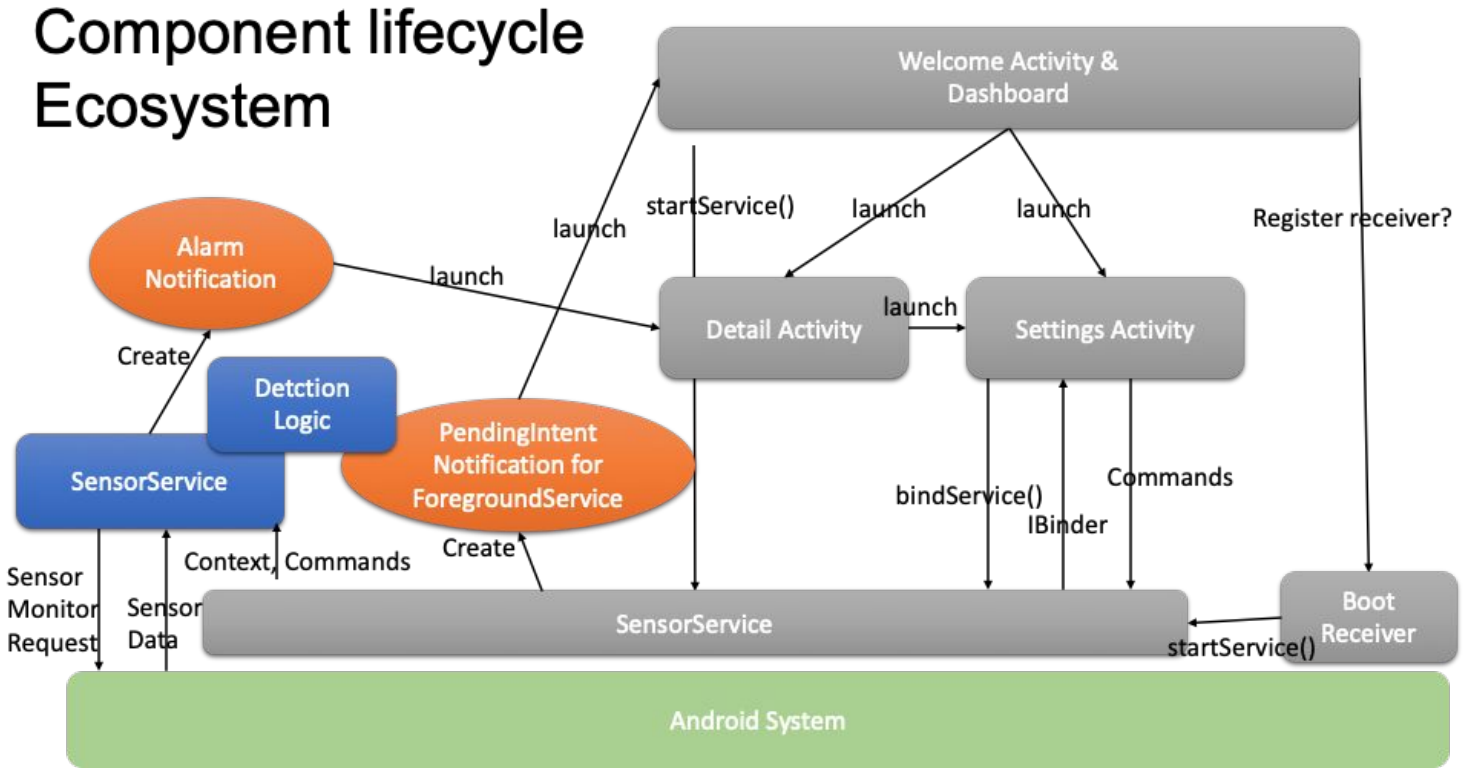


BroadcastReceivers

Activities

LiveData holder object

Deeper view of architecture



The system architecture overview

1. Two apps provided: one for android phone and the other for the android smartwatch.
2. There is a service for getting gyroscope and accelerometer data from smartwatch, and there are two services on android phone: one for listening for the phone's sensor data and one for communicating with the watch.
3. Each services of the phone own their AI models, and they infer whether the user moved for a long time, or detect if the user drank water.
4. Every notifications are managed by SensorService.
5. Communications between all these components are by using Intent, Broadcast, and LiveData.

Key technical challenges & solutions

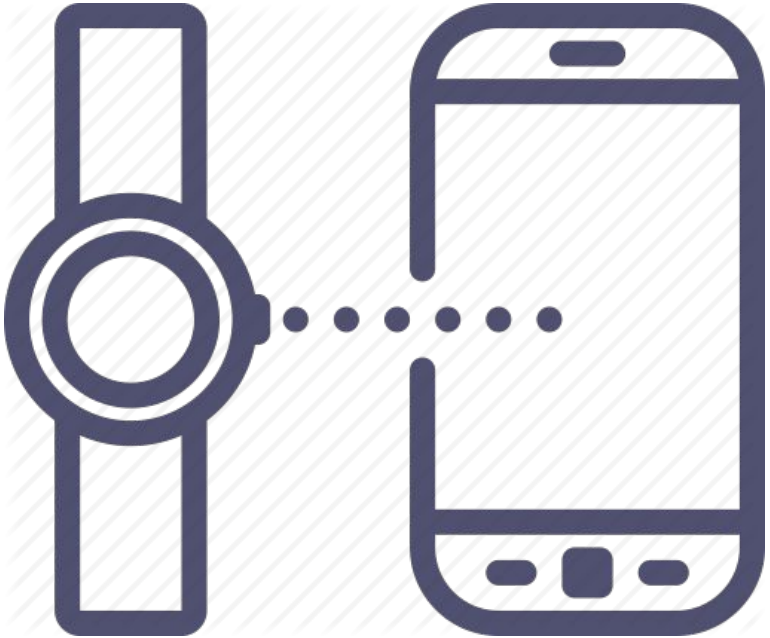
1. The app has to monitor the sensor even when the user is not using the app foreground.
    a. Solved by creating a service
2. The service needs to be started automatically when the phone booting is finished.
    a. Solved by registering a BroadcastReceiver
3. The UI needs to be updated in real time, based on settings and the service's detection result.
    a. Solved by adopting LiveData pattern
4. We have to infer whether the user is moving or sitting, and whether the user drank
    a. Solved by using Weka library
5. The smartwatch and the phone should communicate with each other.
    a. We use google wear api over bluetooth.
6. The app should communicate with user in background with low cost.
    a. We use action-added notifications
7. Latency, Power, Accuracy
    a. Latency: Fine enough
    b. Power consumption: Low (two stage not needed for accelerometer)
    c. Accuracy: 99% for moving motion.

Solution approach 1 : Bluetooth

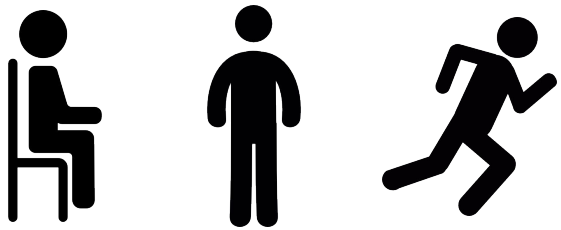
- **Connectivity issues**: Such as any other wireless system, Bluetooth can't be totally reliable. We had to make sure the connection stays continues. To solve this problem, we added parts of code that detects disconnectivity and resends the command to target to re-establish channels.

- **Delay**: We faced delay issues when we asked the smart watch to send many sensor datas all at once. To fixed this issue, we added threads that run in the background to deliver the onSensorChanged messages to the host (mobile)

- **Detect the right target**: Our app cannot connect just to any smart watch. It has to be a paired device that has our wear app installed. When we can't detect a watch as described, we provide the option to add the count manually.



Solution approach 2 : ML, DL model for inference



- Activity detection model
  => Check whether user doesn't move for long time(ex. 60 min)
  => Notify user to stretch

- Drink water detection model
  => Check user drinked or not
  => Give notification to add drink amount when user drank
  => Notify when user doesn't drink water for long time

Solution approach 2 : data collection

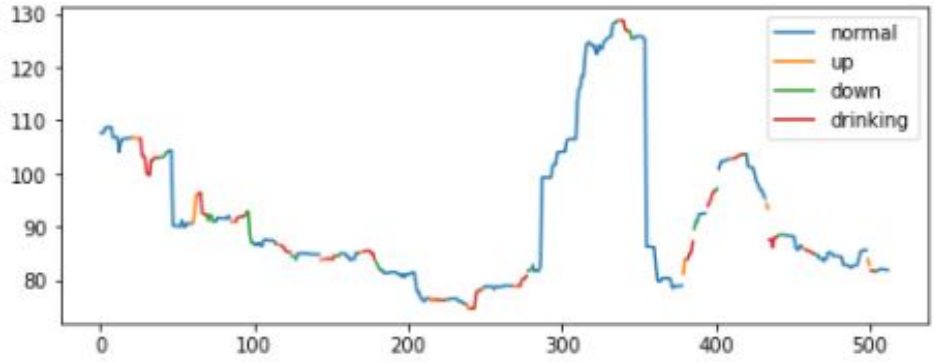
Activity Detection data	
Sensor	Accelerometer, Gyroscope
Label	Sitting, Walking, Running
Raw data dimension	10000 * 6
Total time	15 minute

Water drinking Detection data	
Sensor	Accelerometer, Gyroscope, Heartrate
Label	Normal, up, drinking, down
Raw data dimension	200000 * 6
Total time	40 minute
Participant	4 people(both right, left hand)

Solution approach 2 : Activity Detection model

1. Classifier candidate : NaiveBayes, DecisionStump, RandomForest
2. Find best model
   a. Train/Test split : 7:3 split
   b. Train the classifier candidates.
   c. Check the test accuracy
3. RandomForest was best model
   a. 98% accuracy on test set
   b. Also work fine for the realtime user test
4. Heursitic added
   a. When user is classified as sitting, timer is counting time.
   b. When user classified as walking or running more than 6 second, timer is reset
   c. When timer counts all the left time, stretch notification is given to user

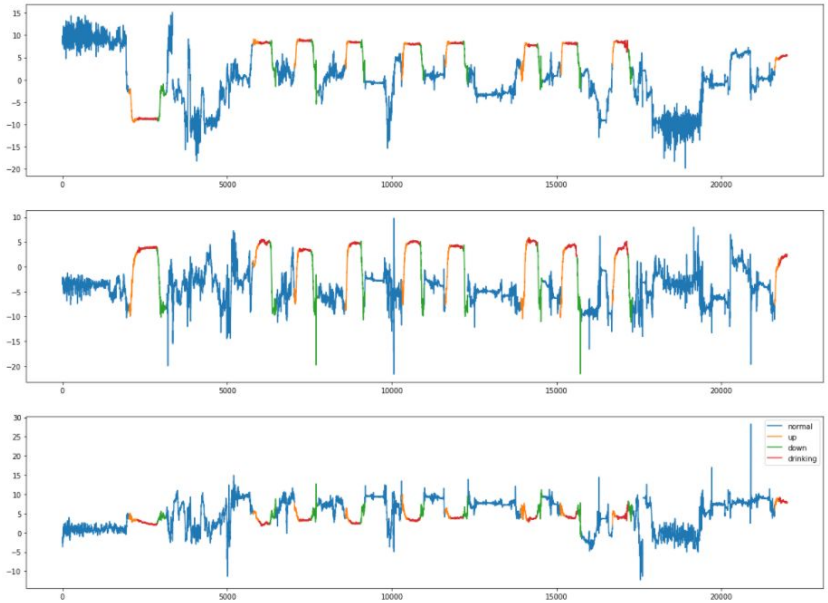
Solution approach 2 : Water drink data EDA



< Heartrate Graph>

- Heartrate didn’t show any pattern for different labels
- It is hard to use on realtime inference, because it is sampled in low frequency
- It also didn’t give accuracy gain on our model

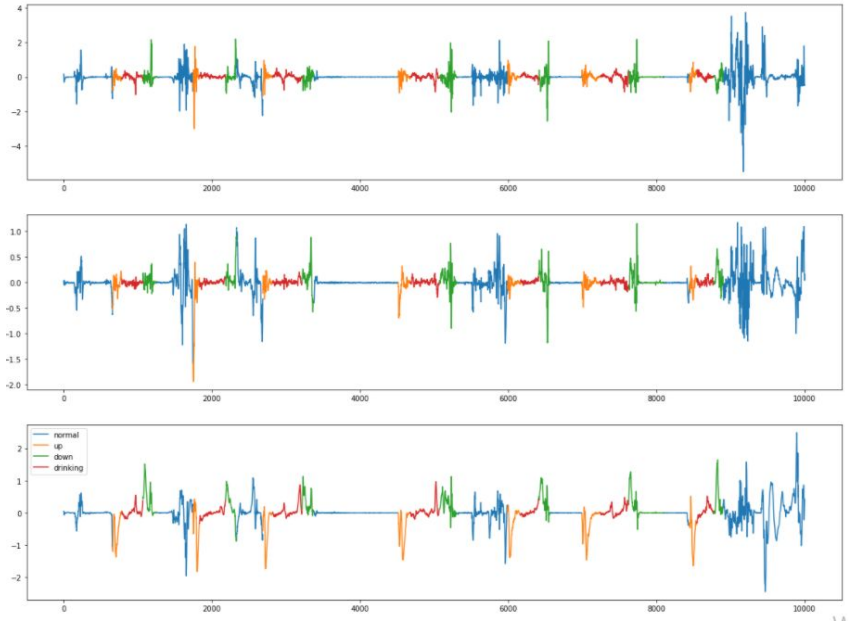
Solution approach 2 : Water drink data EDA



< Accelerometer Graph>

- Accelerometer show clear pattern on different motion
- It uses low battery, with high sampling rate
- It also give lot's of accuracy gain on our model

Solution approach 2 : Water drink data EDA

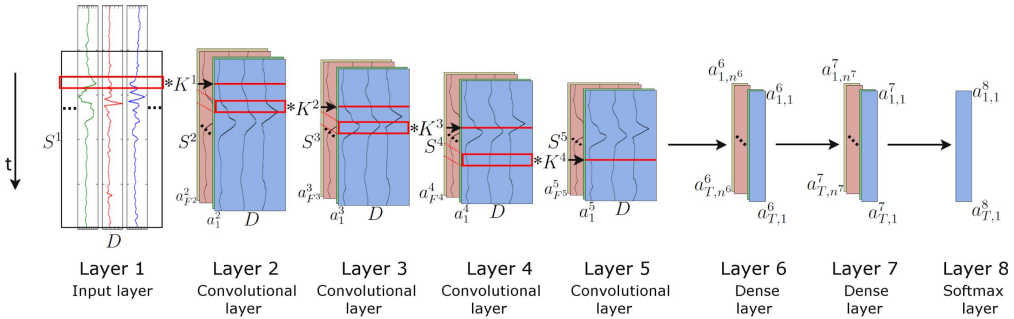


< Gyroscope Graph>

- Gyroscope show some pattern but it is little bit ambiguous with normal pattern
- It uses high battery, with high sampling rate
- It also give small accuracy gain on our model

Solution approach 2 : Water drinking model

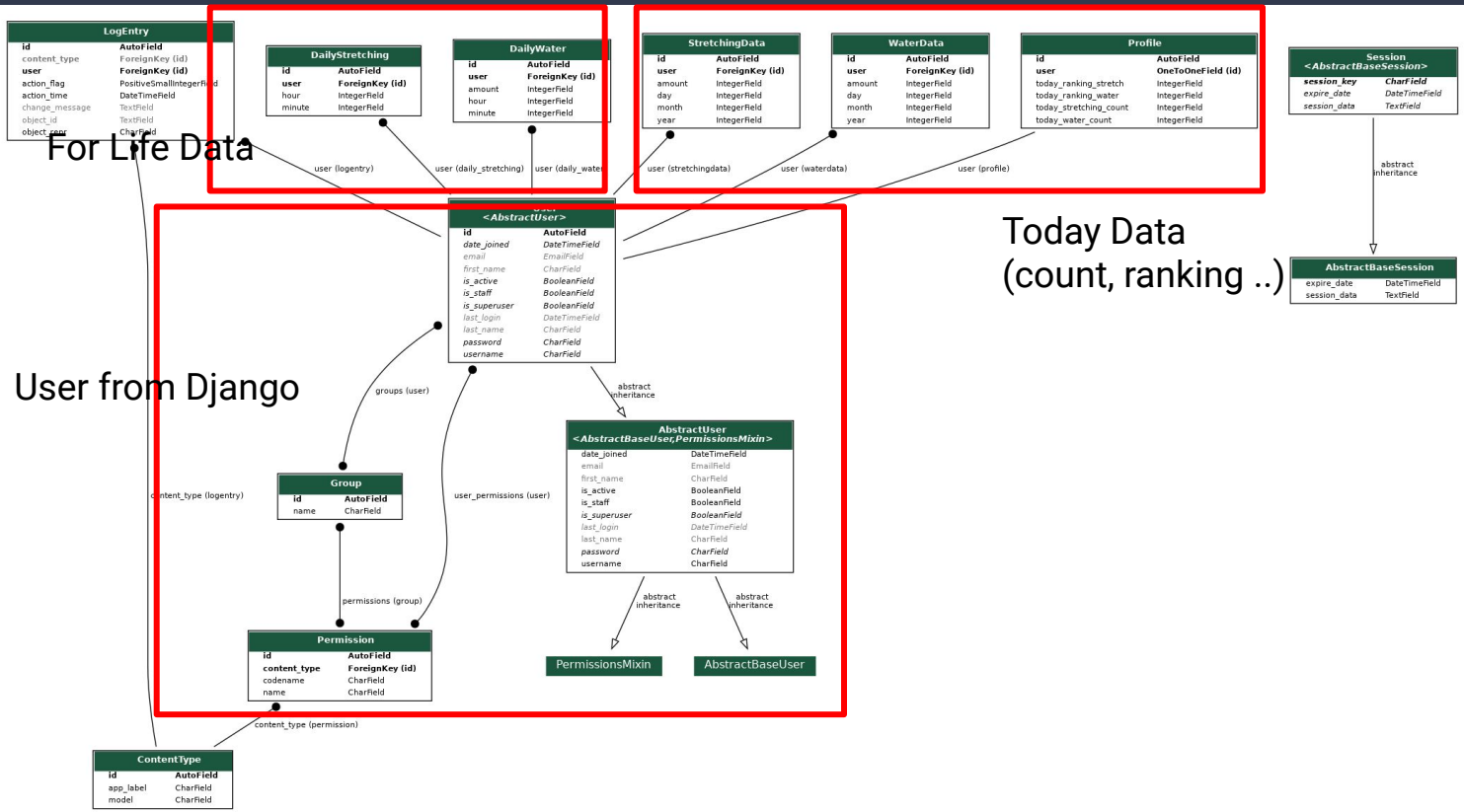
	Model candidates	**Accuracy / F1-score**	**note**
ML	Randomforest	88.2% / 82.0	Feature extraction needed
DL	LSTM	73.4% / 66.6	
	DeepConvLSTM	76.5% / 68.3	



Evaluation Results2 : Inference

Model : RandomForest (with feature engineering)	
Model Accuracy	Gyroscope + Accel : 88.2% / 82.0 Only Accel : 87.1 % / 81.1
Drinking detection Accuracy	Test set : 100% Real time test : about 90%
Latency	About 1 second (Bluetooth : 1 second?, Inference : almost 0)
Power	Approx 0.5% per Hour (Only accel)
Usability	It is little bit unstable on real time

Solution approach 3 : Backend design



Solution approach 4: Notification logic

Initial thought: Chain Observables from the sensor data to notification!

Low experience in reactiveX-tive way of thinking

Use traditional way like callbacks to run tasks based on timing

Final deliverable and success criteria

o Our Final APP

Using sensors of smart phone and watch, without setting fixed time people can get alarmed for their stretching and water drinking at their desired time interval.

To give some sort of accomplishment sense, they will get success batch when they do stretching and drinking.

People can also record and share their health history about stretching and water drinking.

o Our Success Criteria are

If our model for moving gets upper 99% acc, one for water drinking gets upper 95% acc(19 of 20) and other functions(data recording and competing with others) are implemented, we will judge our project succeeds.

Scope of the project

- **Scope is same with Mid,**
- **All our plans were done!**

- ***What are to be done (in Mid)***
  - *Implement bluetooth communication between smartphone and watch*
  - *Improve model accuracy on detecting water drinking by using DL model and feature engineering*
  - *Develop proper backend*
  - *Add community feature like ranking or competition*
  - *Improve UI/UX*
  - *Deploy server*
  - *Testing*

Project schedule – Timeline

- **What were done**
  - Build skeleton app for frontend
  - Gather sensor data from smartphone and watch
  - Develop heuristic/ML model for detecting user status(moving, drinking water)
  - Implement app's background service part for giving notification
  - Implement bluetooth communication between smartphone and watch
  - Improve model accuracy on detecting water drinking by using DL model and feature engineering
  - Improve UI/UX
  - Deploy server
  - Develop proper backend
  - Add community feature like ranking or competition

Project schedule – Things that are done

Feature	Assignee
1. Bluetooth communication	Jasmine & Hyeonseo
2. Backend for user account and data history	UGyeong
3. Improve model accuracy by DL model design and feature engineering	Donghae & UGyeong
4. Improve UI & UX	Jasmine & Donghae
5. Deploy server	Hyeonseo
6. Community feature	UGyeong
7. Testing	Everyone

Git usage stats

Community feature

- **What were done**
  - User can login, logout, and sign up
  - And they can get life data for detail and today data from deployed server
  - User can see other users and their daily ranking

Lessons learnt and reflections

- We read a medical paper that diver's HR becomes lower than 95% of its significance level, and tried HeartRate to detect water drinking motion more accurately but failed(sadly..) -> We learned paper and real situations can be quite different.
- Watches memory and computation strength is not good enough -> need to wisely decide what parts of implementation needs to stay on watch and what should be on mobile.
- Make our work smarter -> collecting user's data and add predictions, user's own model
- And lastly, after A LOT of testing, we realized this couldn't be more true: **"No amount of testing can prove a software right, a single test can prove a software wrong."**

Thank you!