Call:

DATAIA INSTITUTE
Data Science, Intelligence & Society

PEPER

Prosumption Prediction with Machine Learning

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DATAIA-JST International Symposium

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LMD

PRESENTATION OUTLINE:

Definitions

Energy consumption monitoring

Weather forecast for renewable energy

Human behavior/presence

Multimodal machine learning for energy management

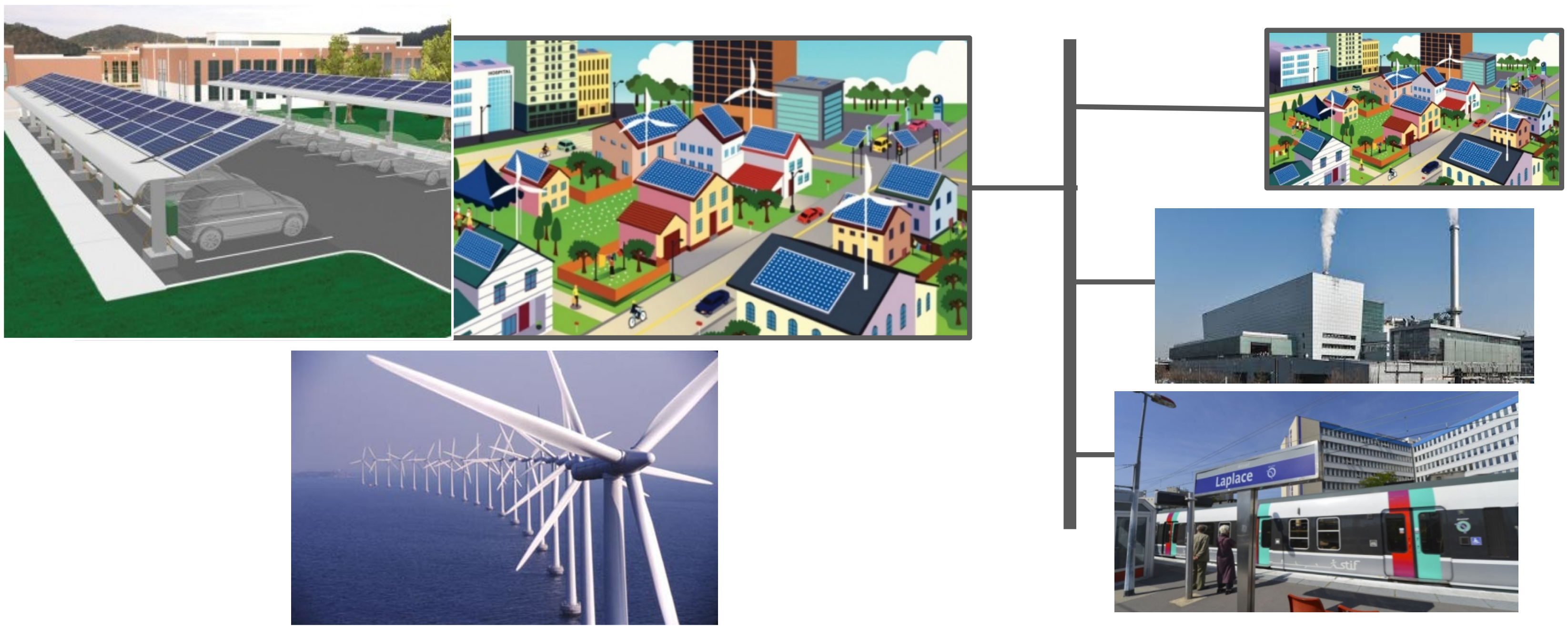
Deep reinforcement Q-learning

Project deployment

Conclusion

MICROGRID,SMARTGRIDS AND PROSUMING

Production / consumption / storage in a microgrid



We need a ‘smart’ mechanism to coordinate those actors :

- At the local scale intra microgrid
- Between microgrids = smart grid

PROJECT OBJECTIVES

- **Consumption, Renewable energy and weather forecast**
- **Smart management of a single building**
- **Recommendations on best coupling between different microgrids**

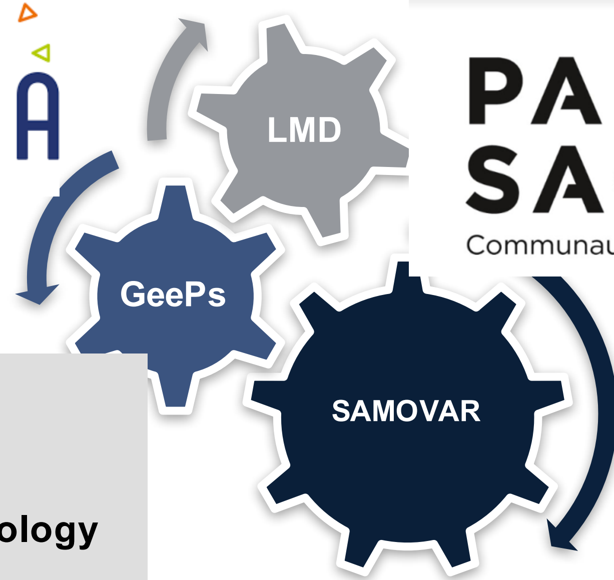
Approach :

- Use multi modal data
- Construct machine learning models (state, action, reward)
- muti-objective reward and multi agent coupling

Scientific challenges :

- Best choice of data and granularity
- Adaptation and evolution of machine learning algorithms
- Go from theory to practice

PEPER PARTNERS



SAMOVAR

Telecom SudParis

Computer science

Telecommunications

LMD

Polytechnique X

LMD - Dynamic Meteorology Laboratory

The laboratory studies climate, air quality, and changes in planetary environment

Laboratoire GeePs

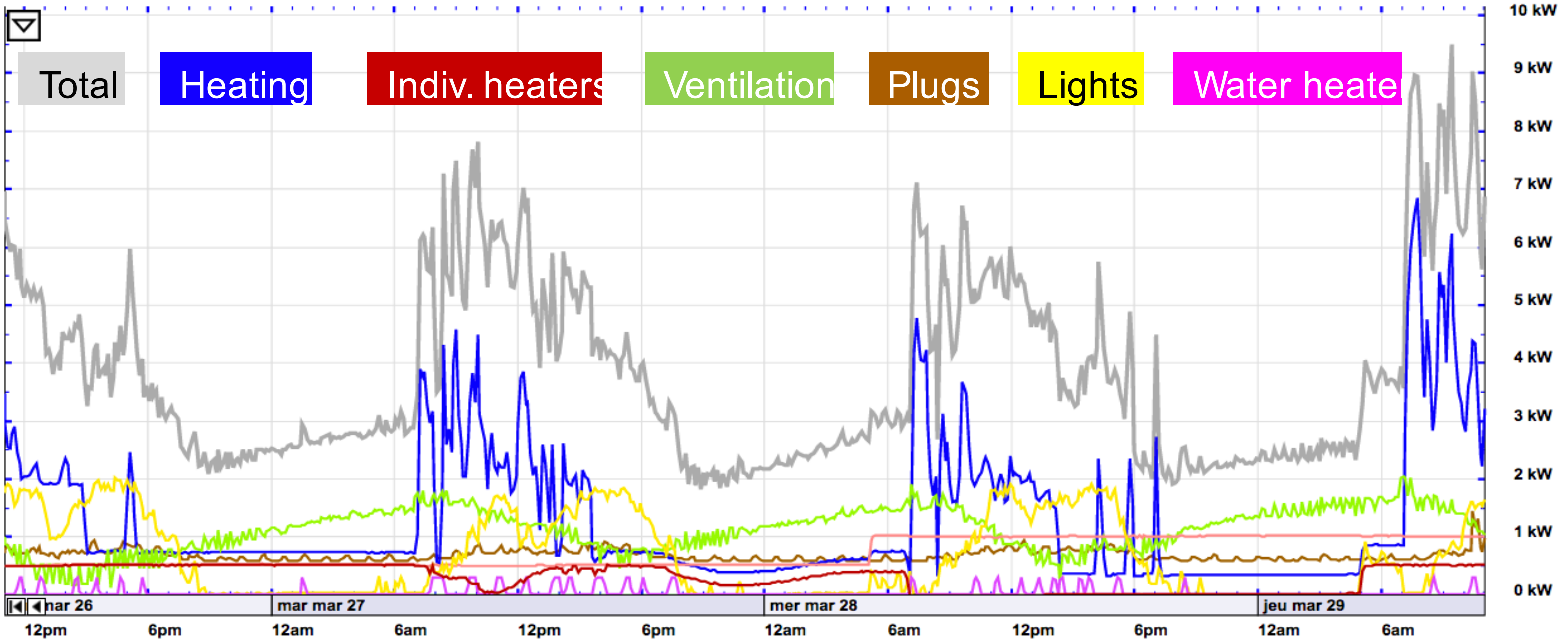
Centrale Supelec

Energy expertise

Open to any collaboration?

WP1: CHOICE & DATA HARMONIZATION

- Electric/energy consumption, …
- Realtime onsite Mesurement (homes, buildings, campus)

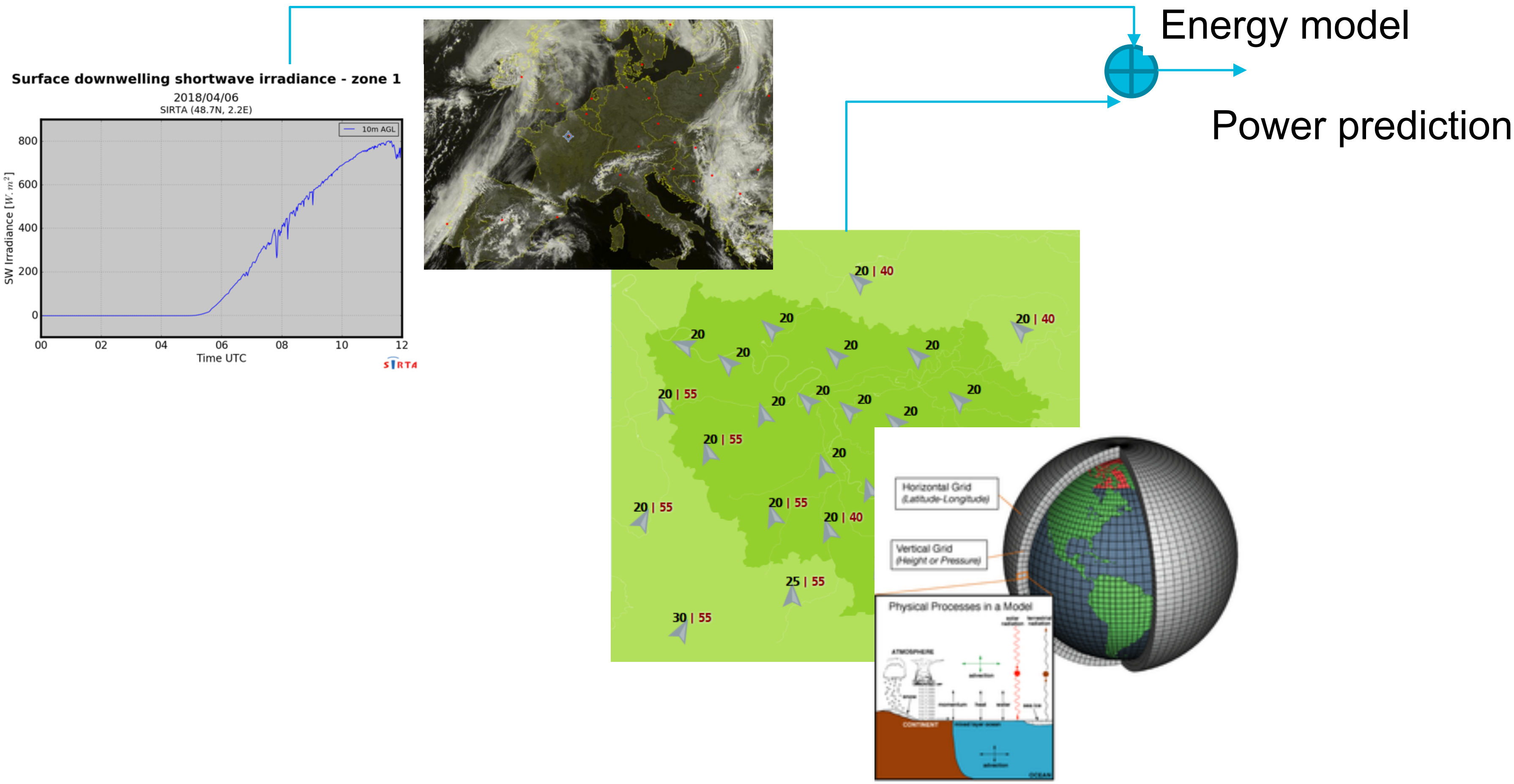


Example: energy consumption monitoring in the :
Drahi-X Novation Center, Ecole Polytechnique

METEOROLOGICAL DATA

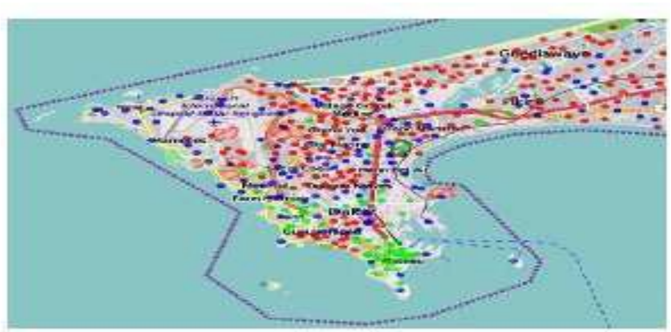
Meteorological data :

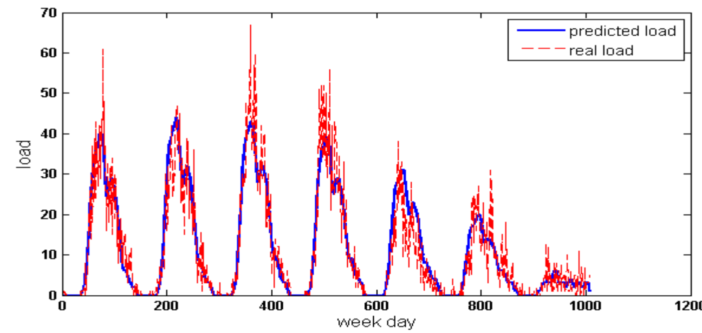
- **Temperatures, wind, sun radiation, rain fall, humidity…**
- **Local measurement, satellite observation, prediction in regions**



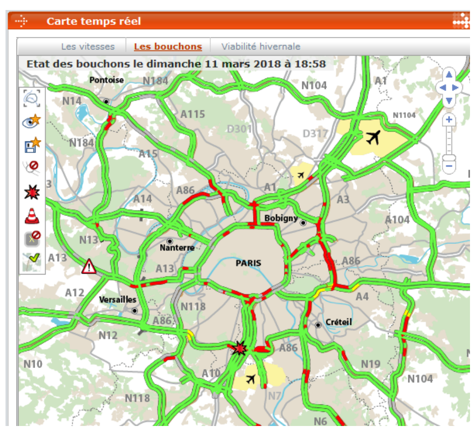
Human presence based on cellular data :

- ▶Fine grain presence based on Cellular data : source Orange, optical Bouygues) :



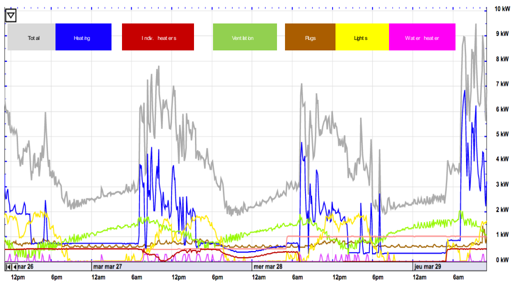


- ▶Road and urban data sources UberMotion, sytadin, waze…

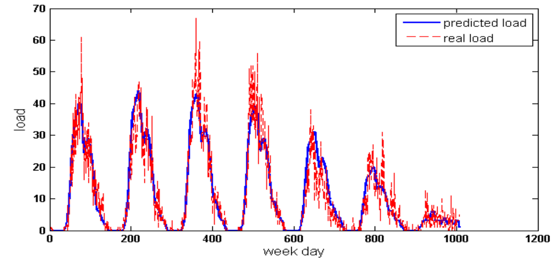


MULTI MODAL MACHINE LEARNING

Realtime data

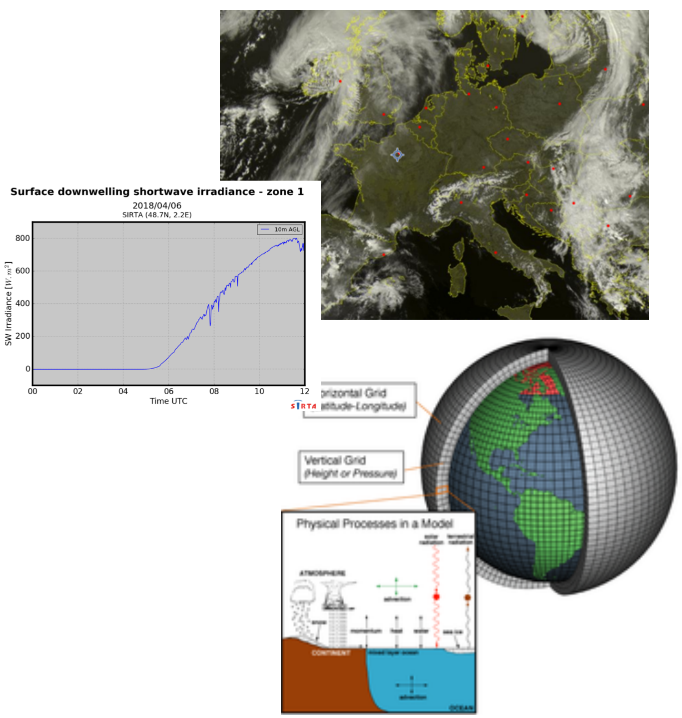


Classified and predicted human presence data

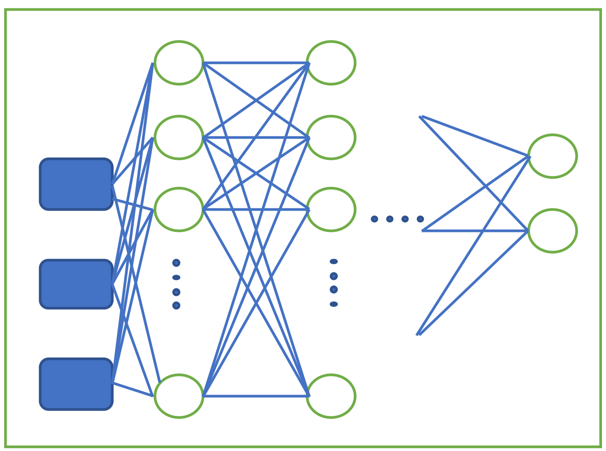


Classification

prediction



Storage/compression



model

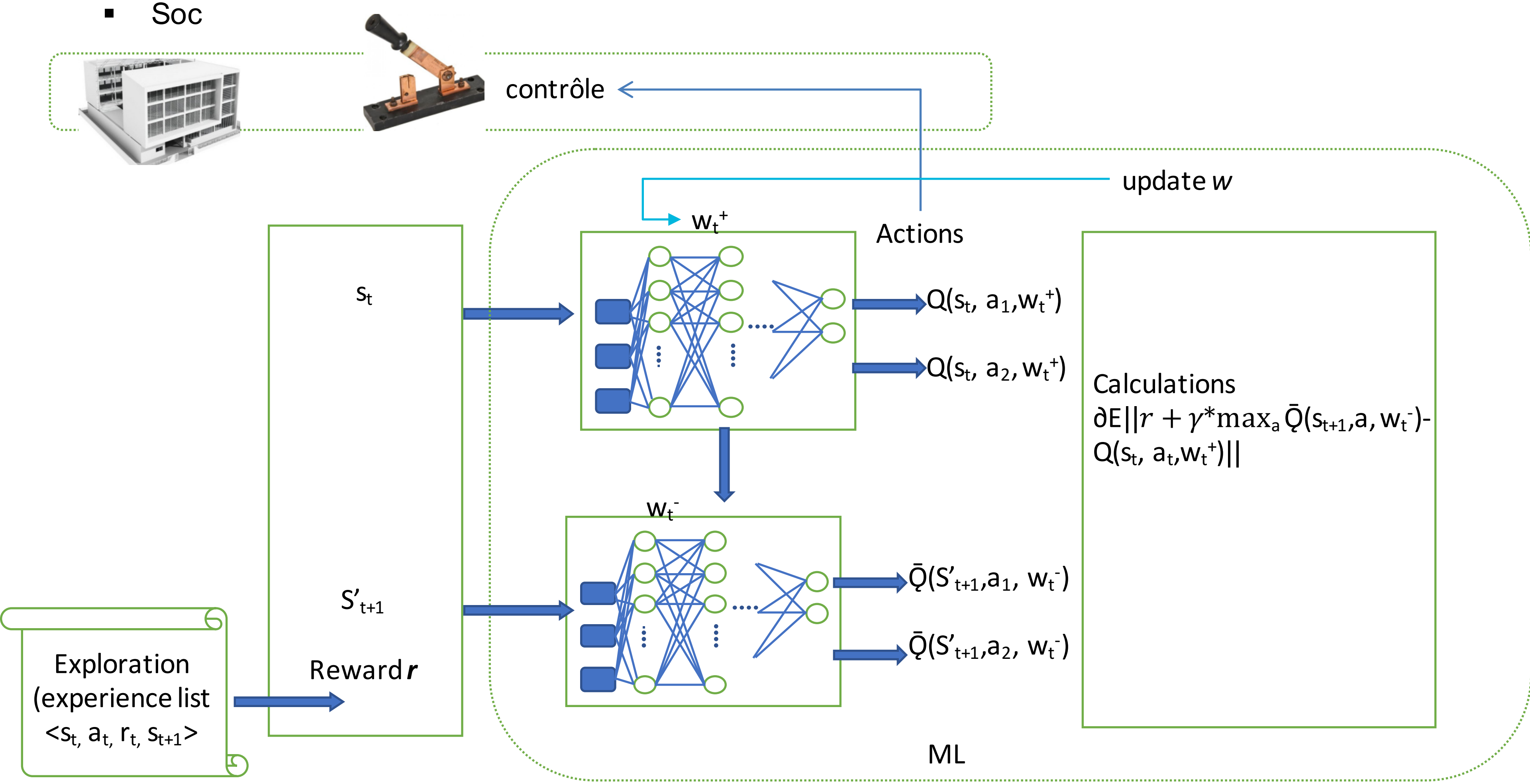
PRELIMINARY CHOICE OF DQN

Example : application of DDQN to utility building

Data (states) :
- Human Presence
- weather (int/ext)
- Soc

actions (decisions) :
- Start / Stop
- Store/displace

Reward (multi-criteria) :
- cost
- Comfort (MVP)

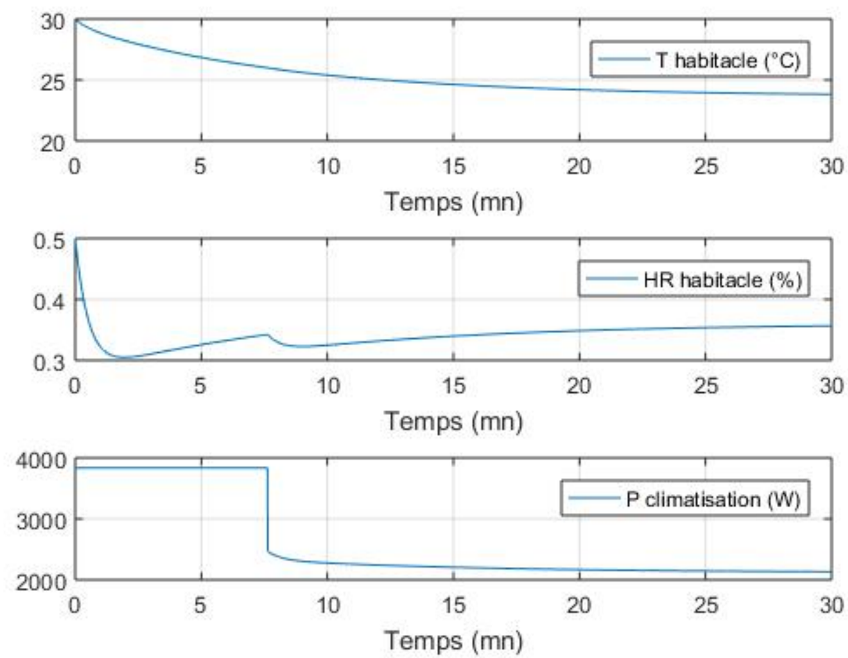


TAKE A SIMPLE EXAMPLE: THE FROZEN LAKE GAME

A SIMPLE EXAMPLE: ELECTRIC VEHICLE TRADEOFF AIR <->MOTOR….

We have a dilemma:

1. Arrive to destination or put yourself confortable?



17°	18°	19°	20°	21°	22°	23°	24°	25°	26°

Source: *Florence Ossart*, et aL. Comparative Study of Real-Time HEV Energy Management Strategies. *IEEE Transactions on Vehicular* Technologies 2017

Our starting point: « Deep Reinforcement Learning »

```
            if d == True:
                #Reduce chance of random action as we train the model.
                e = 1./((i/50) + 10)
                print("finally!!!!!!!!!!!!!!")
                break
        jList.append(j)
        rList.append(rAll)
        """
```

```
s 0
trouve.........j. 16 ............................................
s 43
trouve.........j. 37 ............................................
Saved Model ./dqn/mod49.cptk
s 37
  (Down)
789ABCDSFGHIJKLMNOPQRVTUXYZ123456&*-_~+$/%~#
  (Down)
789ABCDSFGHIJKLMNOPQRVTUXYZ123456&*-_~+$/%~#
  (Down)
789ABCDSFGHIJKLMNOPQRVTUXYZ123456&*-_~+$/%~#
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  (Down)
789ABCDSFGHIJKLMNOPQRVTUXYZ123456&*-_~+$/%~#
  (Down)
789ABCDSFGHIJKLMNOPQRVTUXYZ123456&*-_~+$/%~#
```

```
In [1]: import tensorflow as tf
        import numpy as np
        import gym
        import gym_banana
        #W = tf.Variable(tf.random_uniform([NbStat,2],0,0.01))
```

The project will combine supervised, unsupervised and reinforcement methods

SECOND STEP ADD DISTANCE DIMENSION

4 min (1,5 km)

1. Prendre la direction nord

290 m

2. À 都庁北（交差点）, prendre à gauche

120 m

3. À 新宿中央公園北（交差点）, prendre à gauche

550 m

4. Prendre la bretelle à droite vers 首都高速4号新宿線
   Route à péage

350 m

5. Suivre 新宿料金所 pour rejoindre 首都高速4号新宿線
   Route à péage

160 m

Continuer sur 首都高速4号新宿線 en direction de votre destination à 成田市 取香. Prendre la sortie 高速新空港ＩＣ et quitter 新空港自動車道

59 min (74,4 km)

6. Rejoindre 首都高速4号新宿線
   Route à péage

4,9 km

7. Prendre la sortie 三宅坂ＪＣＴ vers 神田橋・箱崎
   Route à péage

750 m

8. Rejoindre 首都高速都心環状線
   Route à péage

2,5 km

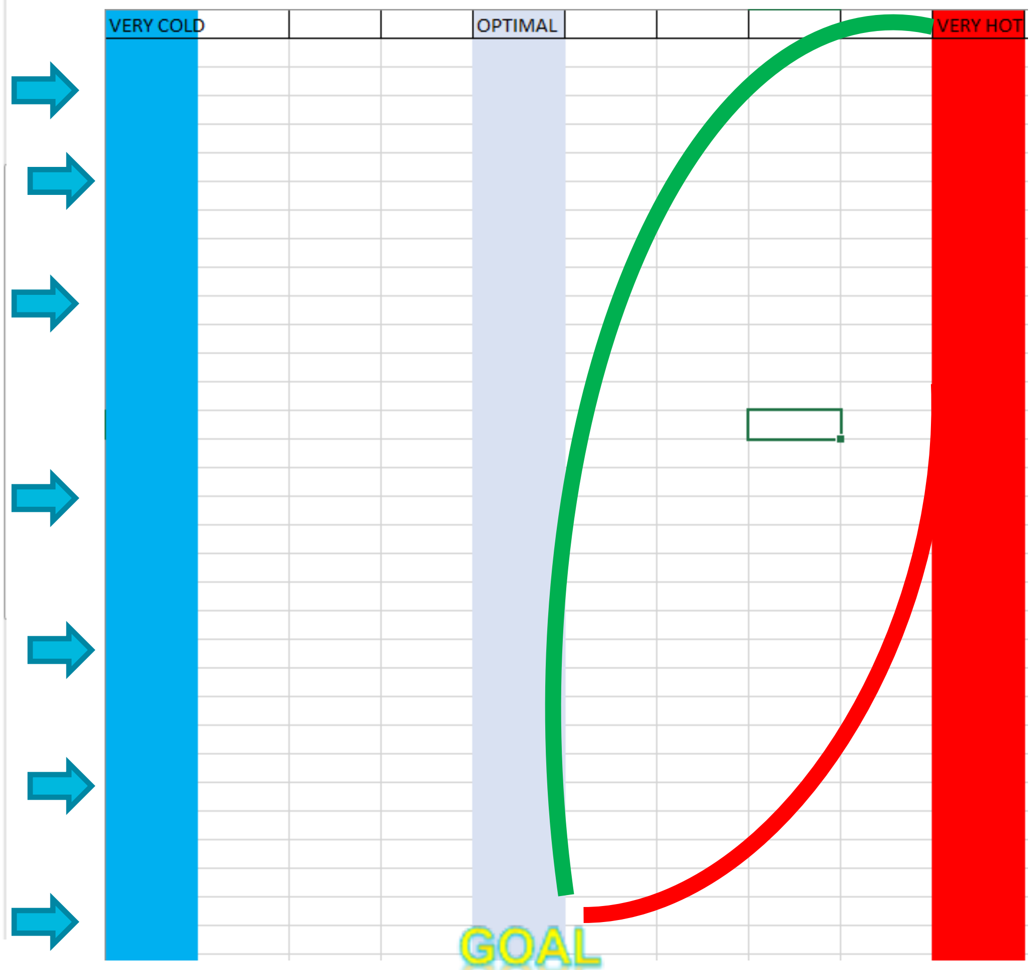
9. Rester à gauche à l'embranchement pour continuer sur 首都高速都心環状線, suivre 箱崎・銀座
   Route à péage

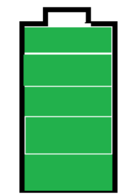
1,1 km

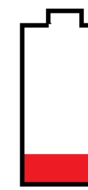
10. Utiliser les 2 voies de gauche pour prendre la sortie 江戸橋ＪＣＴ en direction de 向島・湾岸線・箱崎
    Route à péage

700 m

11. Continuer sur 首都高速6号向島線



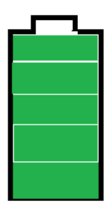




PRELIMINARY TRAINING RESULTS (DQN TENSORFLOW)


```
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
12345678901234L67890123456789012345678901234
   (Left)
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
12345678901234L67890123456789012345678901234
   (Left)
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
12345678901234L67890123456789012345678901234
   (Left)
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
12345678901234L67890123456789012345678901234
   (Left)
```

```
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
12345678901234L67890123456789012345678901234
   (Left)
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
12345678901234L67890123456789012345678901234
   (Left)
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
12345678901234L67890123456789012345678901234
   (Down)
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZA      ~+$/%~#
123456789012341678901234567       8901234
   (Down)
ABCABCD#FGHIJK@MNOPQRVTUXYZA      ~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZA      ~+$/%~#
123456789012341678901234567       8901234
finally!!!!!!!!!!!!!!
```



```
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
12345678901234L67890123456789012345678901234
   (Down)
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
12345678901234L67890123456789012345678901234
   (Down)
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
12345678901234L67890123456789012345678901234
   (Left)
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
12345678901234L67890123456789012345678901234
```

```
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
12345678901234L67890123456789012345678901234
   (Left)
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
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   (Left)
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ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
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   (Left)
ABCABCD#FGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEFGHIJK@MNOPQRVTUXYZABCABC&*-_~+$/%~#
123456789       789012345678901234567890 1234
   (Left)
ABCABCD#F       NOPQRVTUXYZABCABC&*-_~+$/%~S
ABCABCDEF       NOPQRVTUXYZABCABC&*-_~+$/%~#
123456789       78901234567890123456789 01234
```
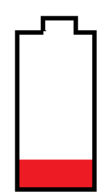
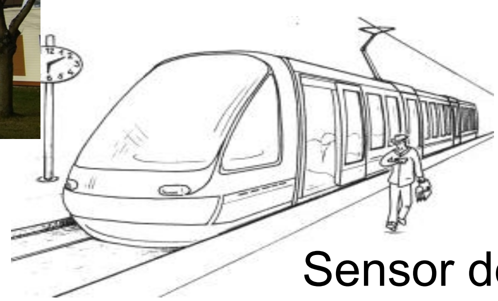



PROTOTYPING

We plan for a distributed plateform around Paris suburb (Saclay-Evry)

- monitoring of several categories of buildings (residential, dorms, official, utility
- Share of data and distribution of ML agents



Sensor deployment, big data deployment, quality control

CONCLUSION

- An energy machine learning project (multi modal data)
- Many prediction algorithms are needed
- A choice of the Deep Reinforcement learning
- Translating problems to SAR will be a challenge
- Prototyping will be a priority
- Open to collaborations