Technical University of Denmark - DTU compute

Pre-print, ODL survey

LBP: Formalizing the on-device learning problem

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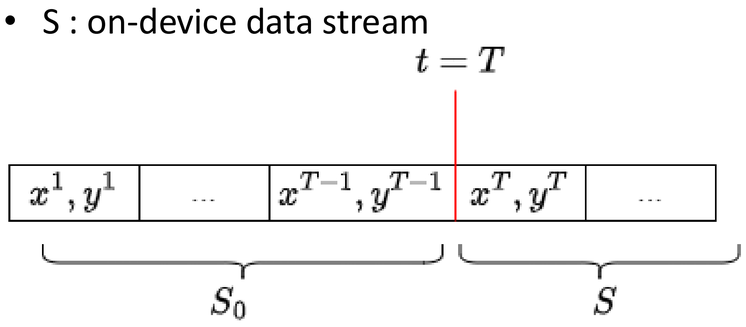
There is little agreement on what doing On-Device Learning (ODL) means, and many ODL works don't consider the constraints of real-world conditions: **limited memory, computation**, and **label availability,** data as a **stream**, **no model validation**. We propose a formalization of the ODL problem that works with different environments and constraints, with the goal of designing reliable solutions in real-world conditions.

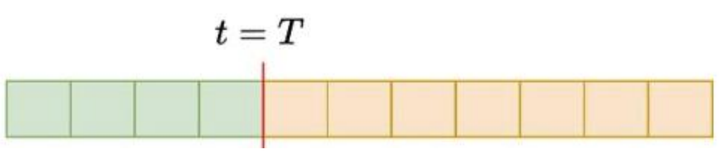
Components of the ODL problem

- Tiny device ***D***
- An ODL solution ***A***
- A data generating process ***P***
  - Provides a pair (x^t, y^t) at each t
  - Sample from $p^t(x,y)$
  - (x^t, y^t) represents the data of a sensor + label
  - At t=T A is deployed on **D**
- S_0 : off-device (pre-)training set
- S : on-device data stream



3 Environments:

- Single change Environments



$$p^{T-1}(x,y) \neq p^T(x,y)$$

- 2 Non stationary Environments

$$\exists t > T \quad p^{t-1}(x,y) \neq p^t(x,y).$$

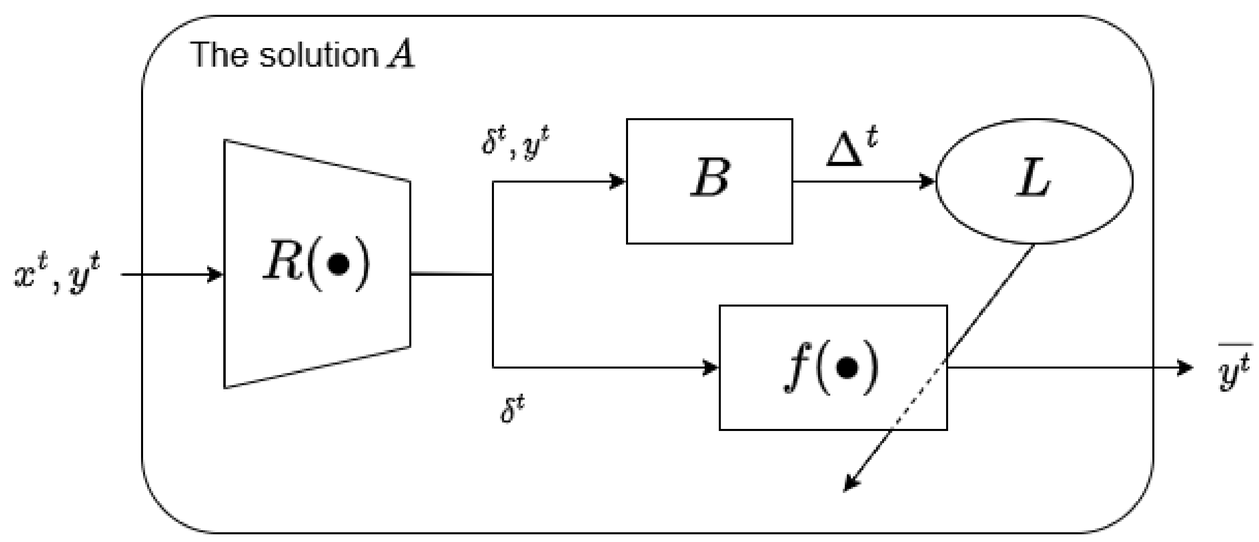
  - Concept Drift Environments
    - Focus on fast adaptation (plasticity)
  - Continual Learning Environments
    - Focus on retaining knowledge (Stability)

Evalutation of the solutions:

- Difficult to validate solutions on-device
- Use multiple "hold-out" data-streams S, available off-device
- Over-time performance monitoring
- Environment specific metrics

Goal: Develop a complete ODL solution ***A*** featuring:

- A feature extraction block ***R***
- A data management policy ***B***
- The ML classifier **f**
- A Learning Mechanism ***L***



Respecting hard constraints on Execution time and memory.

Future Developments: A Library for designing reliable ODL solutions

Problems/Gap in the literature:

- Extremely difficult to compare ODL solutions, due to variability of environments, algorithms and hardwares employed
- Fragmented pipelines, each component optimized independently from each other

We are working on a Library that:

- Helps finding the best **joint** configuration of *R, f, L* and *B.*
- Provides worst-case Memory/Computational requirements for solutions
- Focus on reproducibility (Provides Datasets, baseline implementation for components, metrics and evaluation methods for different environments)
- Focus on extendability (Design easily just a new component, or the complete pipeline, and share them with the community!)

Feedback: What features would make you interested in using it?

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