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# *What are Recurrent Expansion Algorithms? Exploring a Deeper Space than Deep Learning*

**Tarek Berghout[1,*] and Mohamed Benbouzid[2,3]**

[1] *University of Batna 2, Laboratory of Automation and Manufacturing Engineering; 05000 Batna;* ***Algeria****; e-mail: t.berghout@univ-batna2.dz*

[2] *University of Brest; UMR CNRS 6027 IRDL; 29238 Brest;* ***France****; email: Mohamed.Benbouzid@univ-brest.fr*

[3] *Logistics Engineering College; Shanghai Maritime University; Shanghai 201306,* ***China***

* *Correspondance : t.berghout@univ-batna2.dz*



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**Presentation map:**

1) ***Introduction:*** *main research gaps;*

2) ***REMR Algorithms:*** *Definitions, main difference and learning rules;*

3) ***Illustrative examples:*** *classification;*

4) ***Conclusions:*** *Advantages, disadvantages, future opportunities of REMR.*



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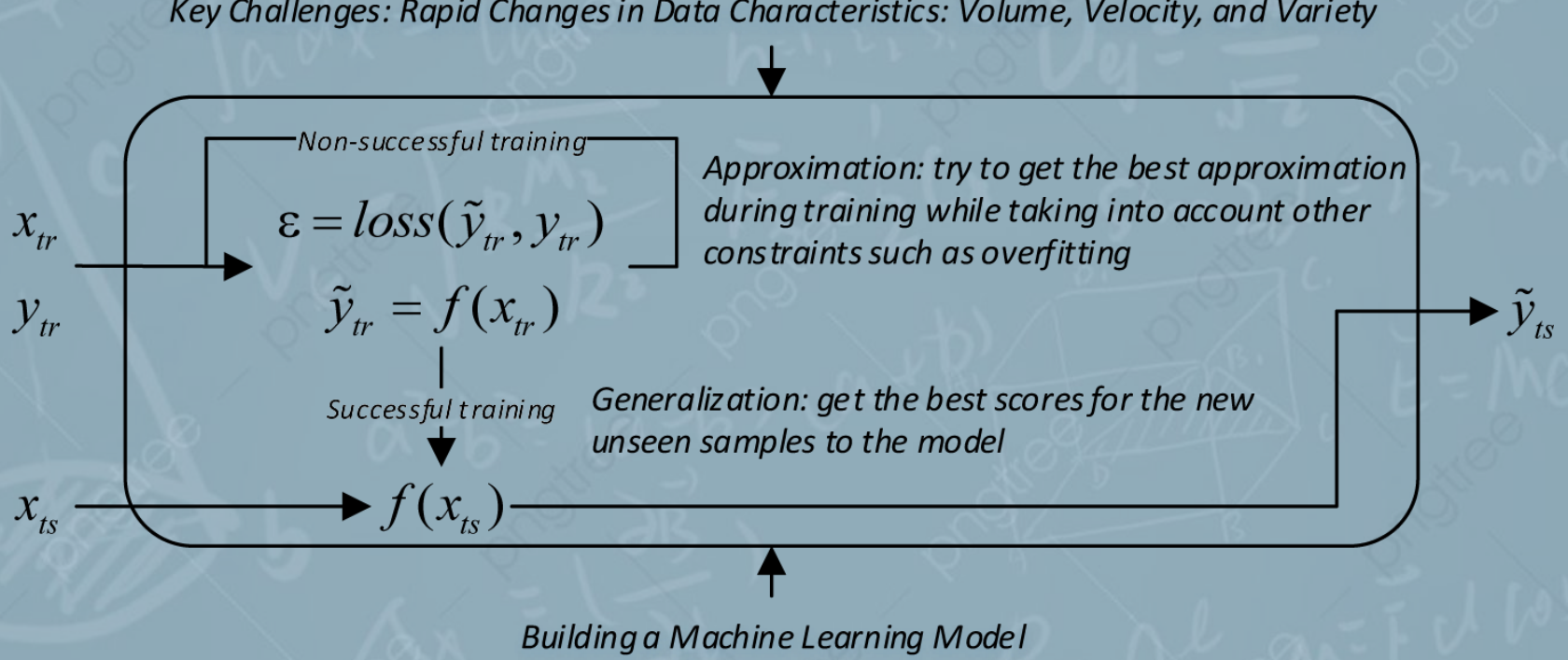
## 1) Introduction: main research gaps



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## 2) REMR Algorithms: Definitions, main difference and learning rules

$$y = f(x)$$

***Machine Learning:*** *Obtain the best approximation by considering optimization of the parameters as the main element of the best generalization*

$$y = f(\varphi(x))$$

***Deep learning:*** *Apart from parameters optimization, representation learning is the main element for improving approximation and generalization.*

$$y_{k+1} = f(\varphi_{k+1}(x_k + 1)) \,|\, k = 1 \rightarrow m$$

$$x_{k+1} = \rho([x_k, \tilde{y}_k, \varphi_k(x_k)])$$

***Recurring Expansion:*** *Merging entire Deep nets including Inputs, Maps, and Estimated Targets (**IMTs**) into other Deep nets consecutively for multiple rounds*



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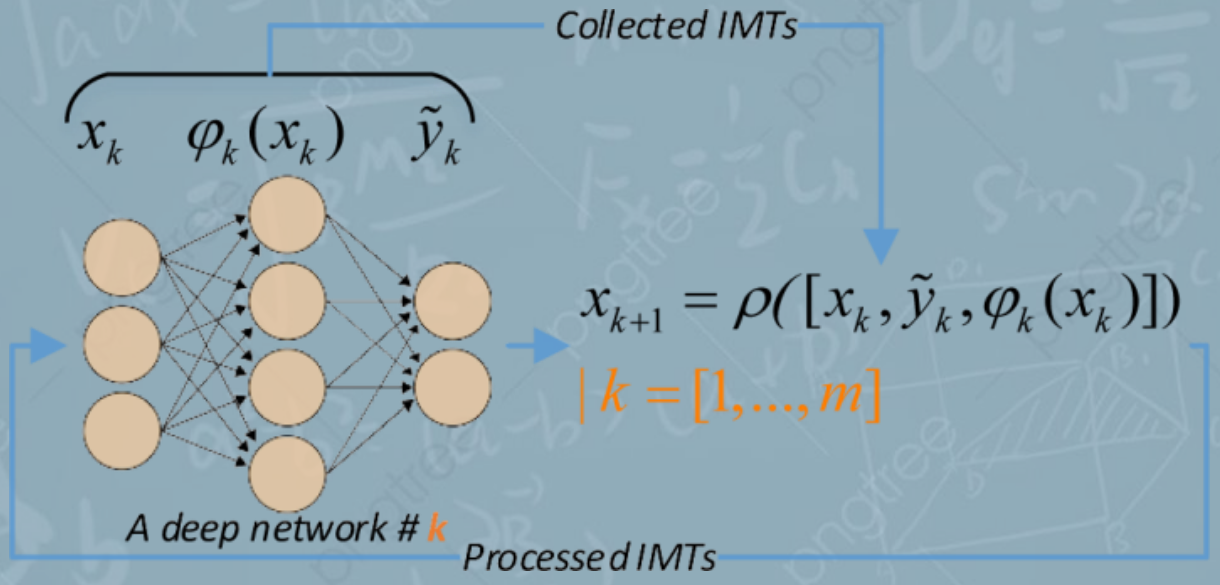
## 2) REMR Algorithms: Definitions, main difference and learning rules




Schematic diagram of REMR Algorithm



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## 2) REMR Algorithms: Definitions, main difference and learning rules

**Inputs:** $x_k, y_k, n_k, ite_k$

**Outputs:** $\tilde{y}_m$

**1)** Start training process

**For** $k = 1 \rightarrow m$

**2)** Train the deep network and collect IMTs

$x_{k+1} = \rho_k([x_k, \varphi_k(x_k), \tilde{y}_k]) | k = [1, .., m]$

**3)** Evaluate the AULC

$$\mathrm{AULC}_k = \int_0^{ite(k)} l_k(x_k)\ dx_k$$

**4)** Reinitialize parameters

$x_k = x_{k+1}$

**End(For)**

Learning steps of REMR Algorithm



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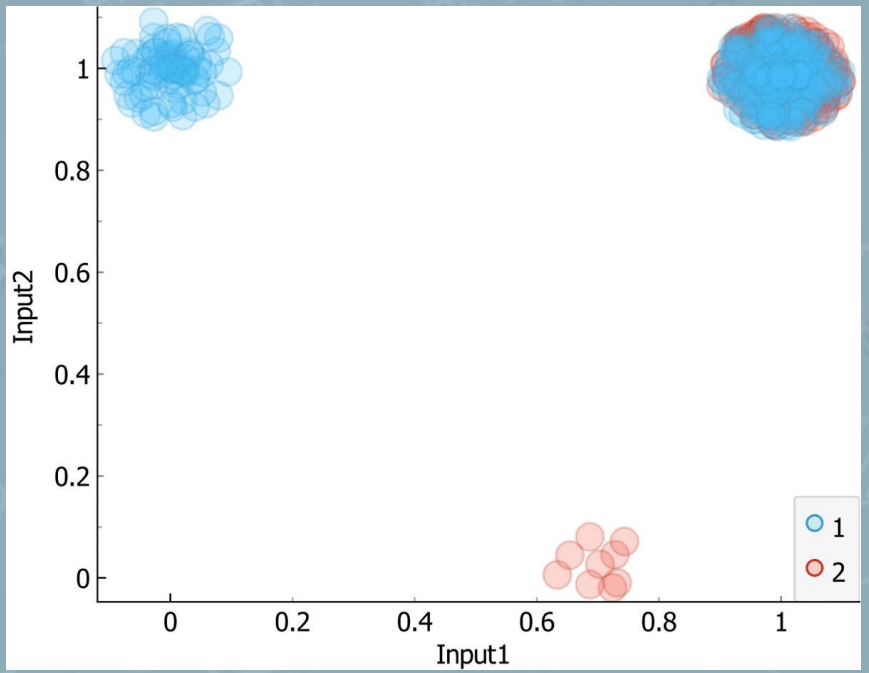
## 3) Illustrative examples: classification (20 rounds with LSTM REMR)




**Animated IMTs improving process through REMR**

T. Berghout, M. Benbouzid, and M. A. Ferrag, "Deep Learning with Recurrent Expansion for Electricity Theft Detection in Smart Grids," in *IECON 2022 – 48th Annual Conference of the IEEE Industrial Electronics Society*, Oct. 2022, pp. 1–6, doi:. 10.1109/IECON49645.2022.9968378

## 4) Conclusions: Advantages, disadvantages, future opportunities of REMR

### *Advantages of REMR*

- *Improve feature representations through understanding different IMTs of different deep networks;*
- *Providing a new source of information, such as estimated targets, helps to introduce additional knowledge;*
- *Building an REMR algorithm does not require much intervention;*
- *Improve feature representations and also the correction of outliers.*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## 4) Conclusions: Advantages, disadvantages, future opportunities of REMR

### *Disadvantages of REMR*

- *REMR requires more computational power than ordinary deep learning;*
- *Stacking in the inappropriate IMTs will cause the AULC function to diverge, which could lead to a worse outcome at each round;*
- *IMTs initialization is evaluated by the basis of errors and trials, which means that it takes a lot of intervention when rebuilding the model at this stage.*

## 4) Conclusions: Advantages, disadvantages, future opportunities of REMR

### *Future opportunities of REMR*

- *Target IMTs initialization problems by performing experiments on IMT selection and optimization in a few primary rounds. This will be useful in deciding whether we go with this model or not without consuming a lot of computing resources throughout the training rounds;*
- *Explore available REMR architecture inspired by ensemble learning and parallel architectures to help deliver even better initial IMTs.*


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## *Thank you*

*On behalf of the co-authors of manuscripts* **[sciforum-069586]**, *I would like to thank the* **IOCMA** *committee for contributing to the success of this event. Also, I would like to thank* **mathematics** *editors for this golden opportunity to showcase our work. I would also like to thank everyone who sponsored and helped make this event happen, including all the journals and contributors to this event.*