Dauphine | PSL
UNIVERSITÉ PARIS

Data science project
Final presentation

Exploiting word embeddings for machine translation

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I - Supervised method

Recall

X : French embedding space

Z : English embedding space

Find linear transformation W

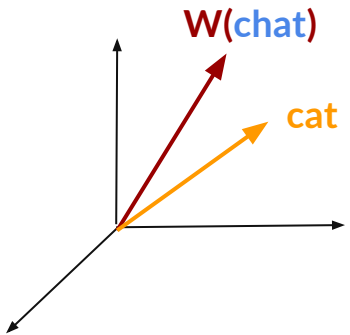
Chat → Cat

translation

$x \in \mathbb{R}^{300}$

0,23	1,45	...

$Wx \in \mathbb{R}^{300}$



I - Supervised method

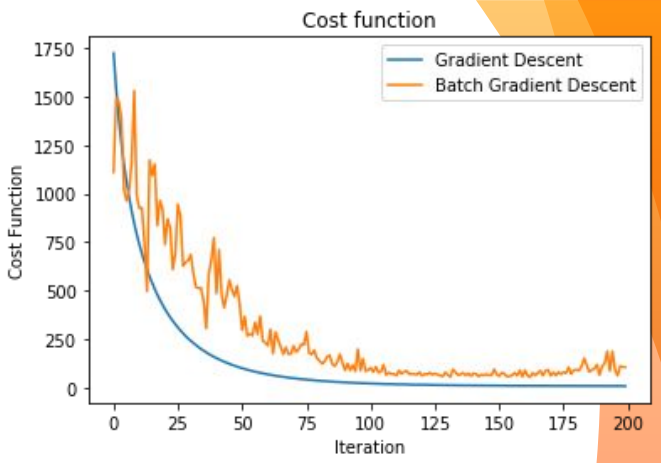
Recall

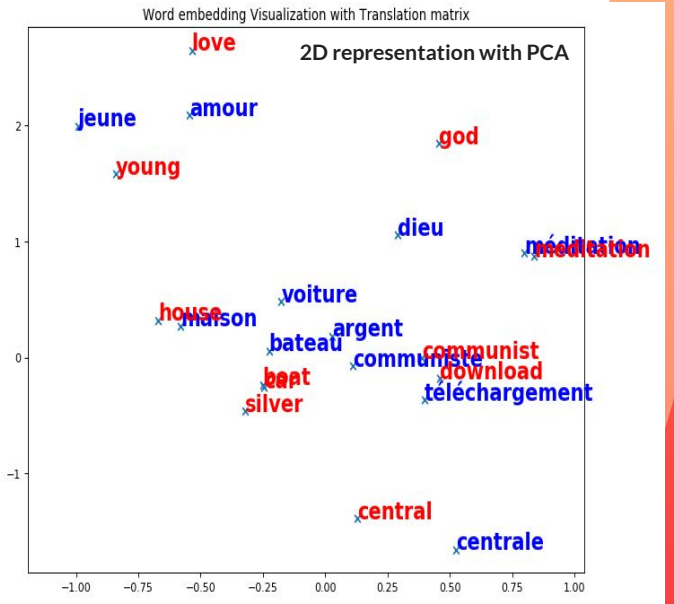
- Minimization of matrix translation
  (4 methods implemented : SD, SGD, MGD, analytical)

$$\min_{W} \sum_{i=1}^{n} \|Wx_i - z_i\|^2$$

- Using cosine similarity to find the closest in the target language space

$$similarity : \frac{< x_i, z_i >}{\|x_i\| * \|z_i\|}$$

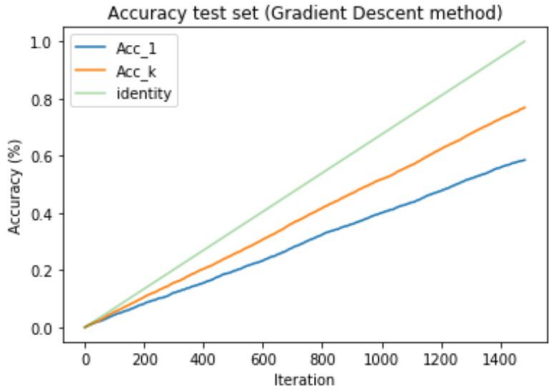




Supervised translator : results for different languages

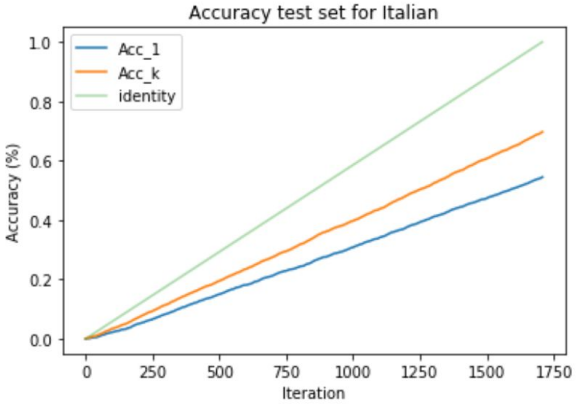
Accuracy top @1/5 words

From French to English



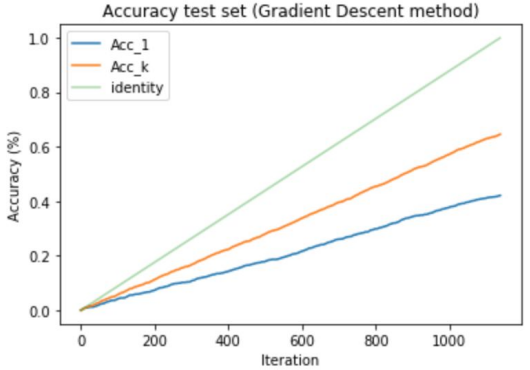

```
Gradient descent method :
Final accuracy @1 = 58.46 %
Final accuracy @5 = 76.8 %

Analytical method :
Final accuracy @1 = 60.22 %
Final accuracy @5 = 77.14 %
```

From Italian to English

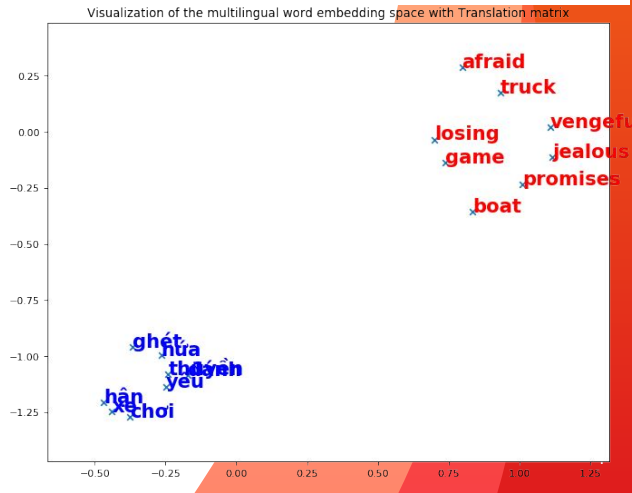



```
Analytical method :
Final accuracy @1 = 54.45 %
Final accuracy @5 = 69.67 %
```

From Vietnamese to English




```
Gradient descent method :
Final accuracy @1 = 42.09 %
Final accuracy @5 = 64.59 %
```

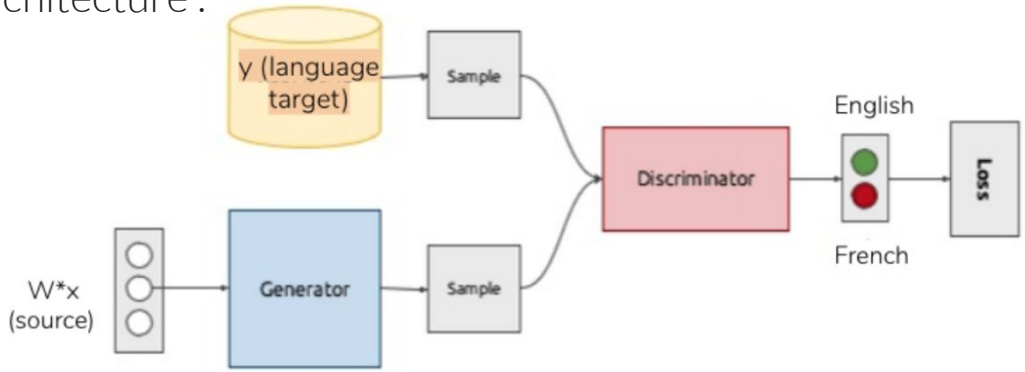


Good results with supervised translator !

II - Build an efficient unsupervised translator

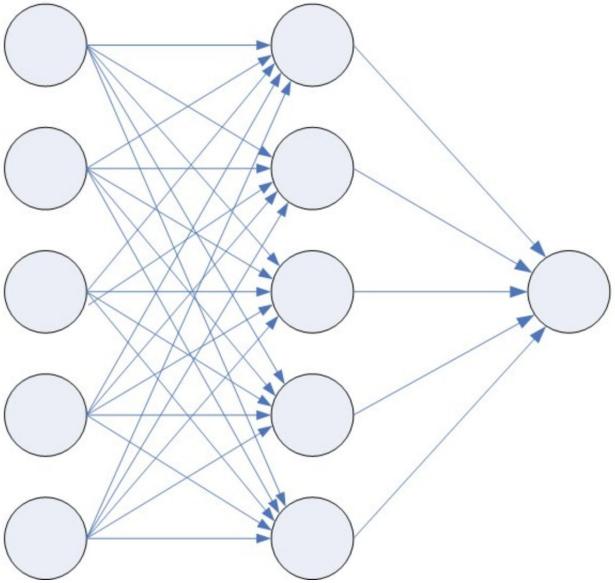
Generative Adversarial Network (GAN) method

- We don't know the traductions ;
  We just have collections of words in source & target spaces
- Two adversarial neural networks :
  - the ***generator*** generates new data instances ("fake" data)
  - the ***discriminator*** evaluates data for authenticity
- **Objective :** Learn the matrix W by training fake (**W*x**) and real (**y**) data
- GAN's architecture :



Unsupervised Translator : GAN
Discriminator

Neural network



Inputs =

{W(chat);
House;
W(voiture);
W(soleil);
University;
W(étudiant); … }

Outputs =

{P(W(chat) ∈ source);
P(House ∈ source);
P(W(voiture) ∈ source);
P(W(soleil) ∈ source);
P(University ∈ source);
P(W(étudiant) ∈ source); … }

Unsupervised Translator : GAN
Discriminator

$$\mathcal{L}_D(\theta_D|W) = -\frac{1}{n}\sum_{i=1}^{n} \log P_{\theta_D}\left(\text{source} = 1 \middle| Wx_i\right) - \frac{1}{m}\sum_{i=1}^{m} \log P_{\theta_D}\left(\text{source} = 0 \middle| y_i\right).$$

- W matrix is fixed
- 3 layers Neural Network takes an embedding as input and returns the probability that this embedding comes from source language
-
- **Objective :** minimize the loss, adapt the weights of the network in order to recognize with high precision the language of the embedding

Unsupervised Translator : GAN
Generator

"fake" data

$$\mathcal{L}_W(W|\theta_D) = -\frac{1}{n}\sum_{i=1}^{n} \log P_{\theta_D}\left(\text{source} = 0 \middle| Wx_i\right) - \frac{1}{m}\sum_{i=1}^{m} \log P_{\theta_D}\left(\text{source} = 1 \middle| y_i\right).$$

- 1 layer "Neural Network" : takes an embedding x as input and returns the "translation" Wx
- **Objective :** Minimize the loss + adapt the weights of the network = weights of W in order to generate embeddings close to those in target space

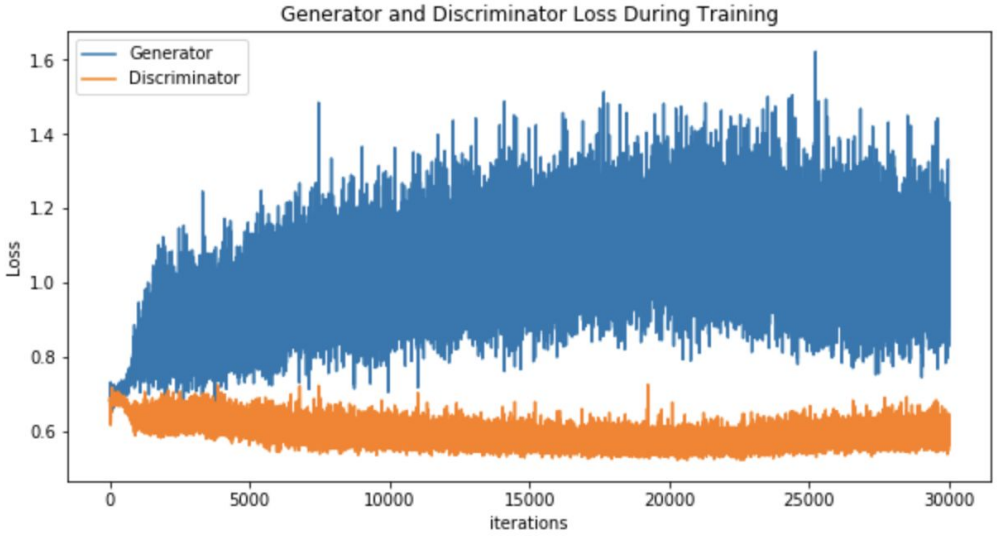
Then, train by SGD with BCE loss function

Unsupervised Translator : GAN

Results

Tried to implement the GAN and played with all possible parameters :

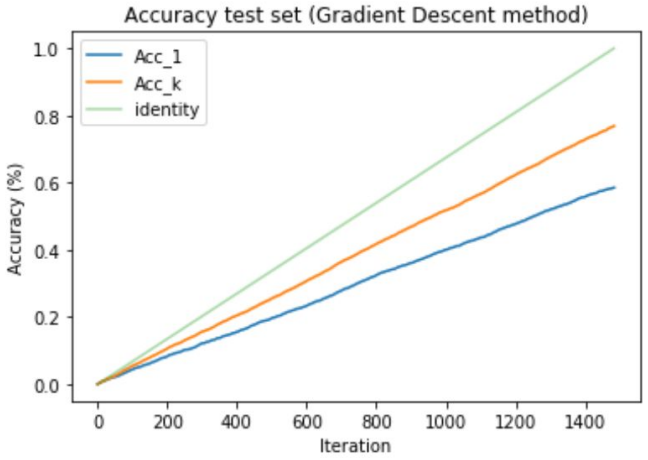
- Nb of iterations
- SGD learning rate
- Nb of hidden layers discriminator
- Add smoothing
- Training spaces
- Nb of words in batch
- Initialisation of networks' weights



Need a large number of iteration to work (longer the training is, better we converge towards optimal W)

Unsupervised Translator : GAN

Results

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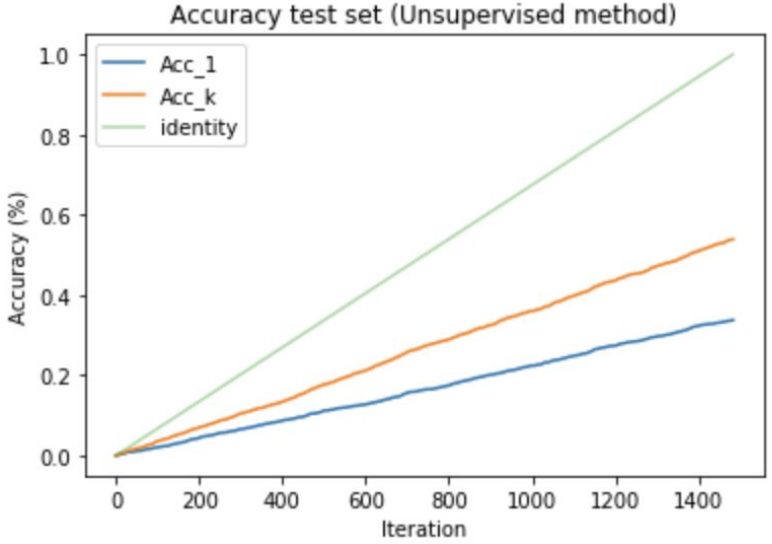


```
Unsupervised method :
Final accuracy @1 = 33.72 %
Final accuracy @5 = 53.88 %
```

Not bad !

Unsupervised Translator : GAN

Results : examples of traductions

```
bateau --> traduction : ['sailboat', 'boat', 'boats', 'moored', 'mooring']
--
maison --> traduction : ['townhouse', 'cottage', 'upstairs', 'farmhouse', 'house']
--
argent --> traduction : ['gold', 'silver', 'bullion', 'bronze', 'valuables']
--
ordinateur --> traduction : ['computer', 'mainframe', 'workstation', 'virtualization', 'computers']
--
dieu --> traduction : ['god', 'divine', 'gods', 'almighty', 'deity']
--
```

Thanks!

Any questions?