COMMENT L'IA EXPLICABLE PEUT-ELLE COMPLÉMENTER L'INDICE D'APNÉES HYPOPNÉES ?

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SLEEPONLINE 2025

MESSAGE 1

AI WON'T REPLACE CLINICIANS, BUT CLINICIANS WITH AI WILL REPLACE CLINICIANS WITHOUT AI

COMPLÉMENTARITÉ VS. AUTOMATISATION

IA en clinique du sommeil :

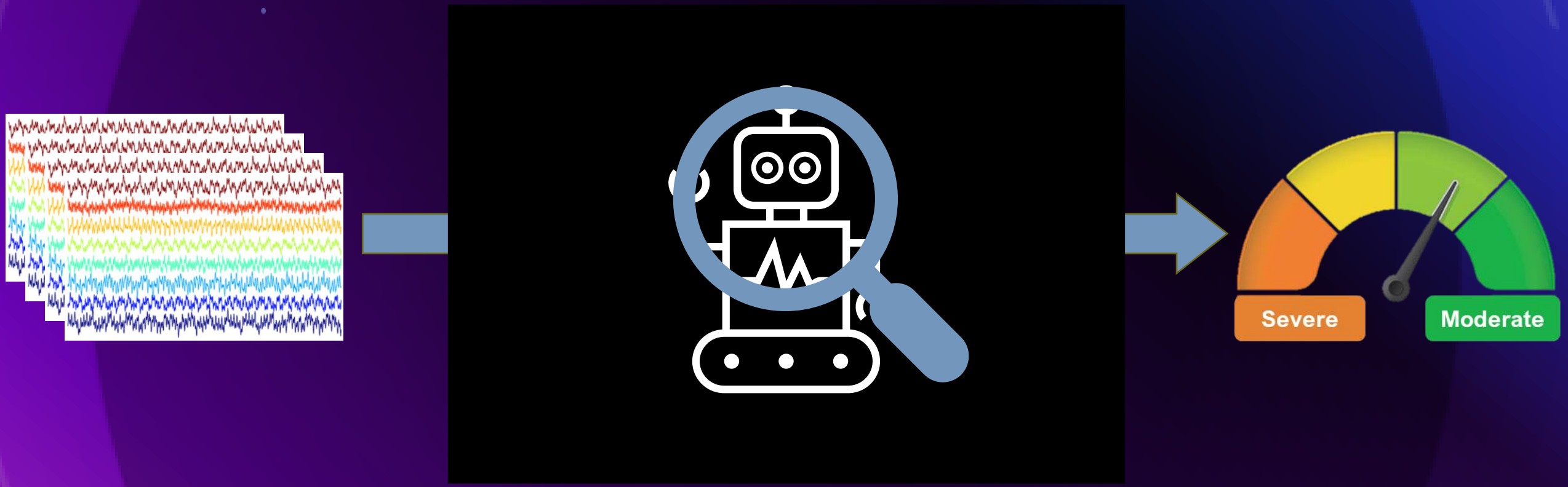
- Détection automatique des événements respiratoires
- Annotation automatique des phases du sommeil
- Limites : précision variable, manque d'interprétation clinique

➔ **adoption faible**

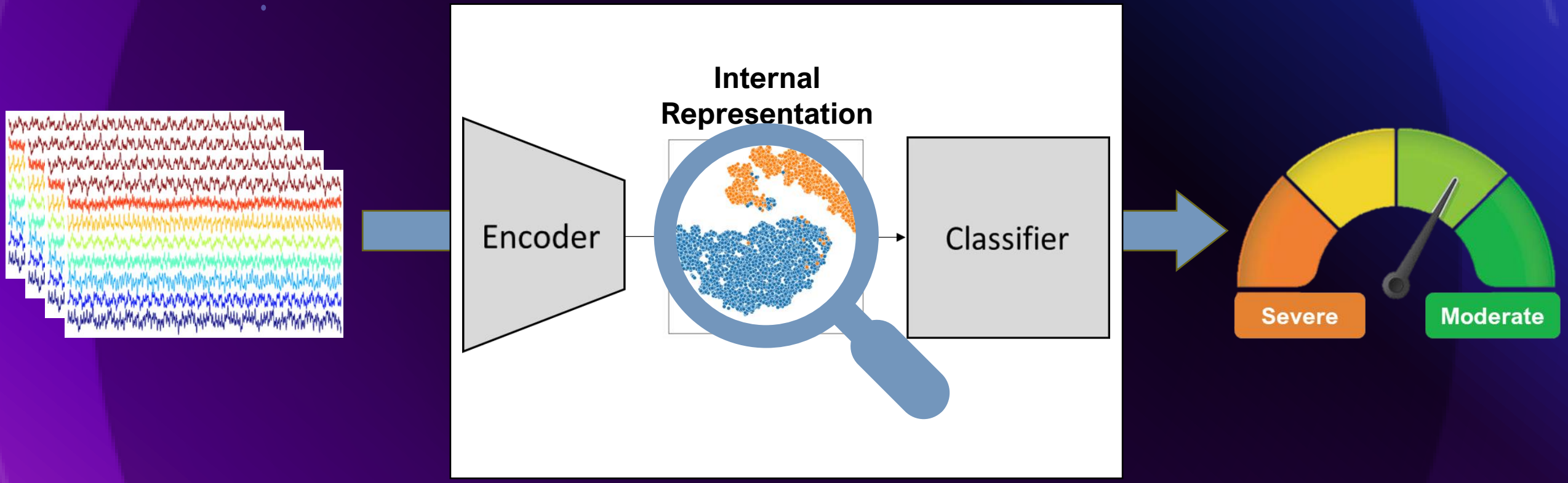
Notre vision :

- Conserver l'expertise humaine : Annotations manuelles ou semi-automatisées
- Utiliser l'IA comme **outil d'exploration physiologique** des signaux
- Focus sur la sévérité des événements annotés

➔ Importance de l'**explicabilité**



Comment ?


Internal
Representation
Encoder
Classifier
Severe
Moderate

Pourquoi ?

MESSAGE 2

PAS DE CONSENSUS UNIVERSEL, MAIS PLUTÔT UNE APPROCHE MULTI-DIMENSIONNELLE

BEYOND AHI

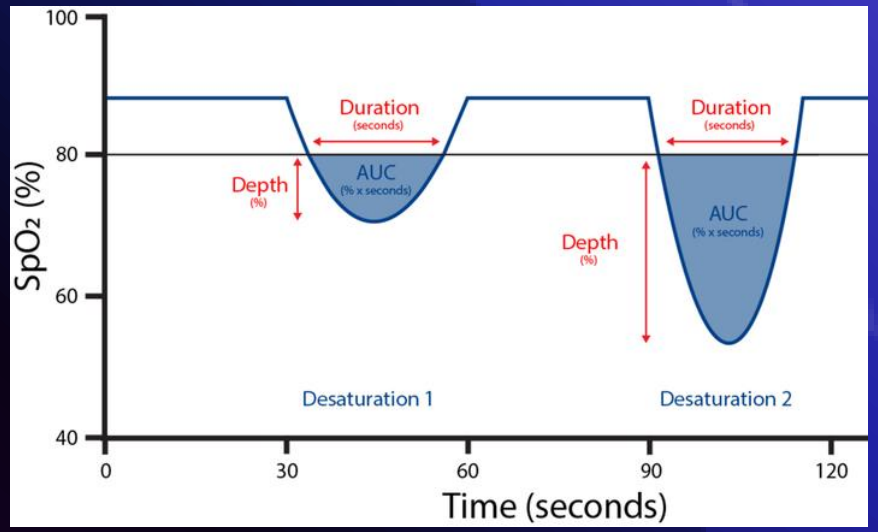
- Pas de consensus scientifique sur LA meilleure métrique isolée
- Besoin d’un score de sévérité physiologique, pas seulement statistique
- Intégrer des dimensions complémentaires :
  - Modulation cardiaque chronique
  - Fragmentation corticale
  - Stress oxydatif
  - Activation sympathique

Modulation cardiaque chronique

➔ PRV

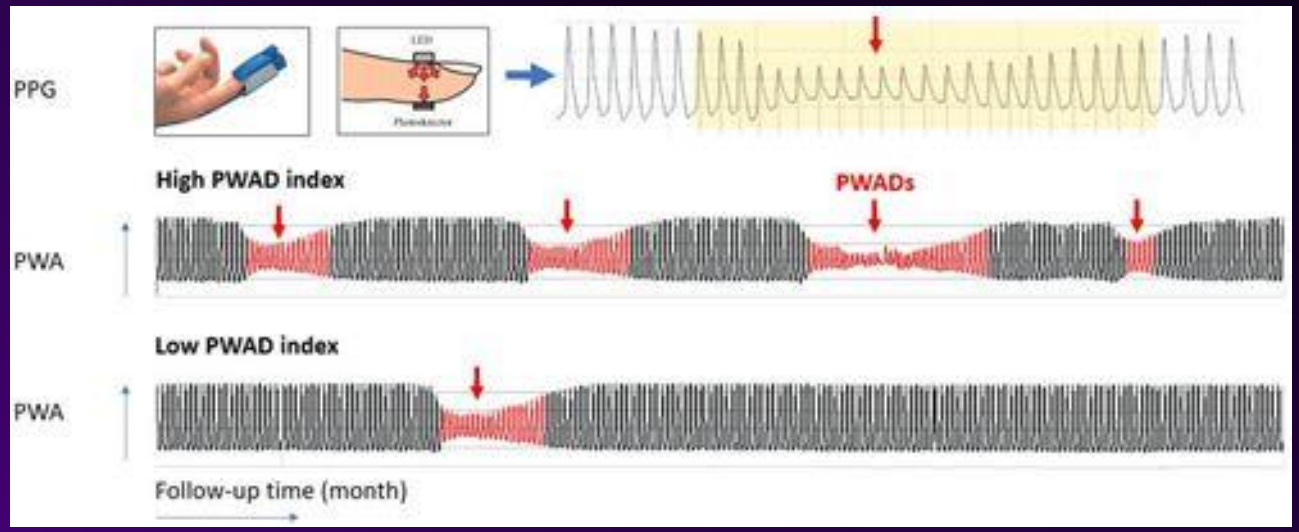
Fragmentation corticale

➔ Arousals



Stress oxydatif

➔ Desaturation Area



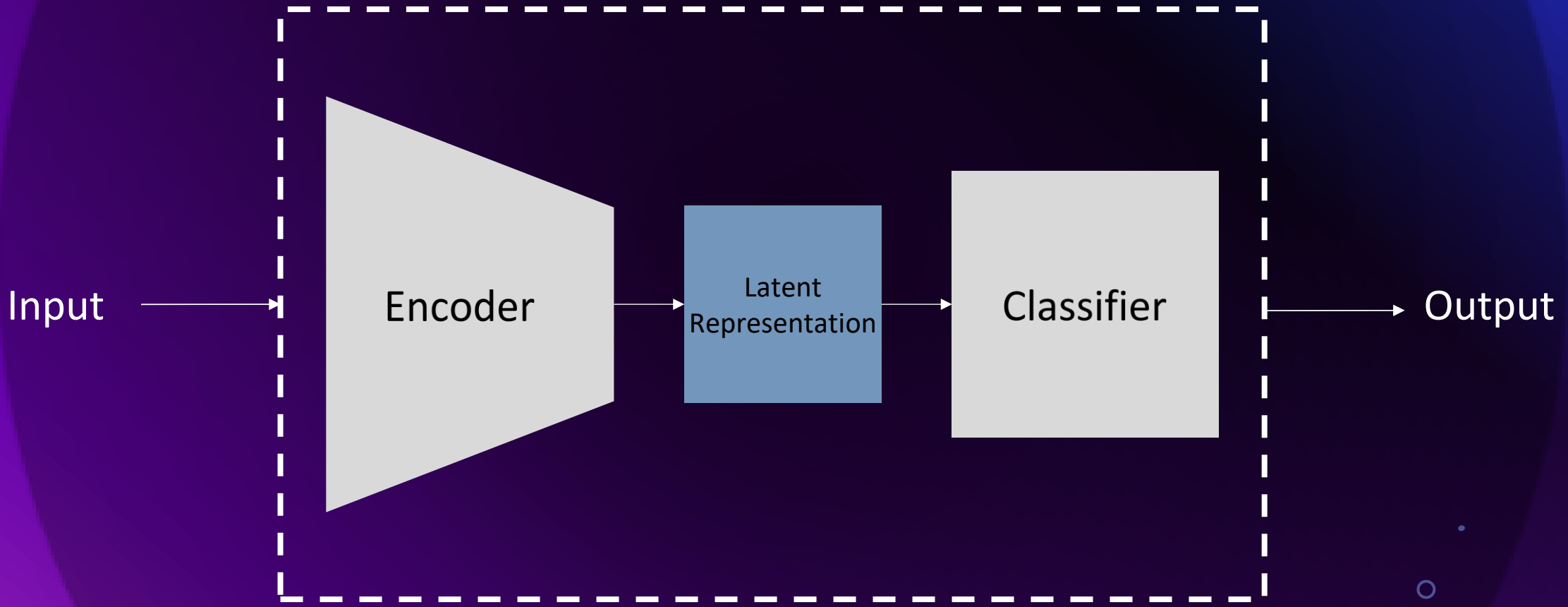
Activation sympathique

➔ PWAD

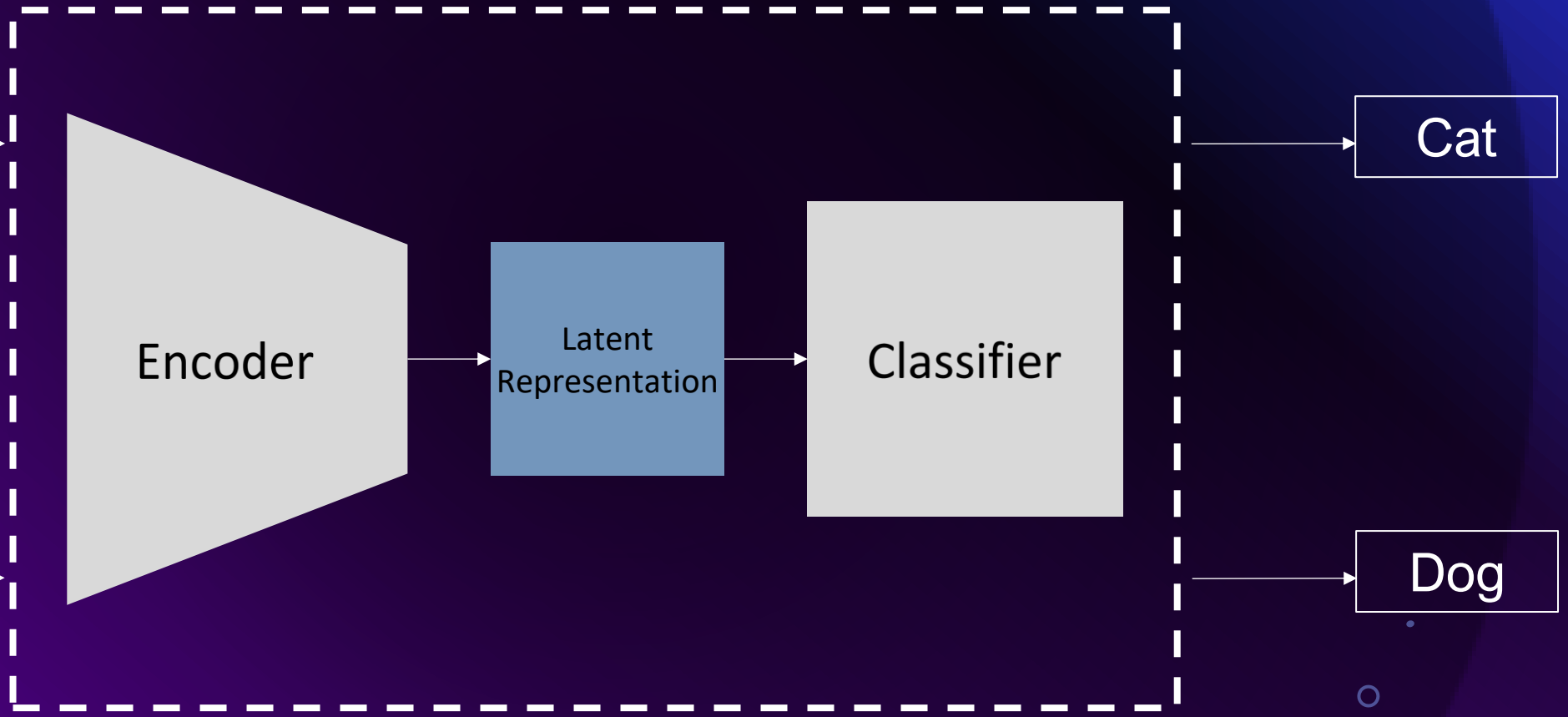
MESSAGE 3

MÉTHODE D'EXPLICABILITÉ BASÉE SUR LA COMPARAISON ENTRE LES ÉVÉNEMENTS

MODÈLE D'IA

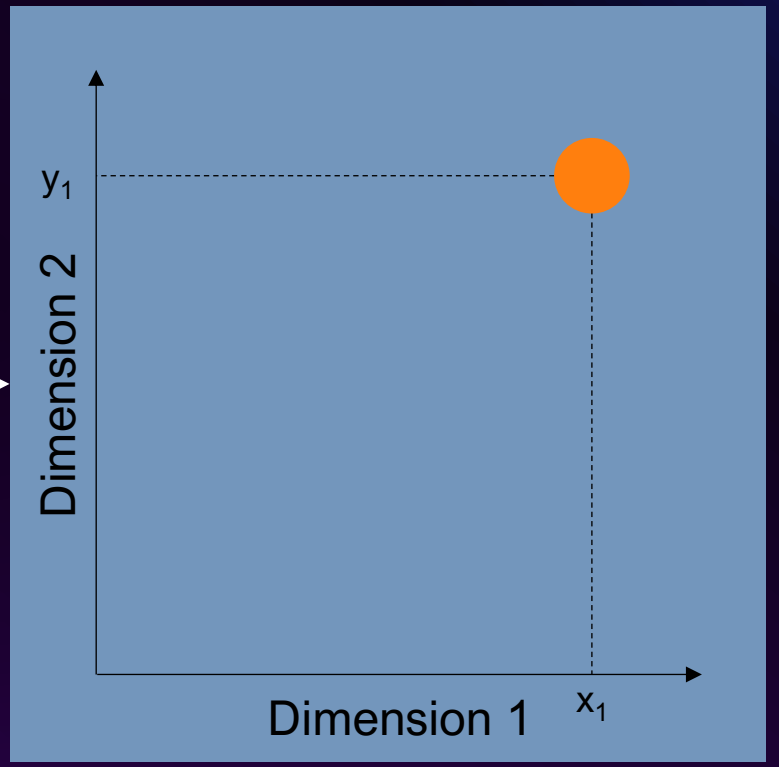


MODÈLE D'IA



REPRÉSENTATION LATENTE

Encoder



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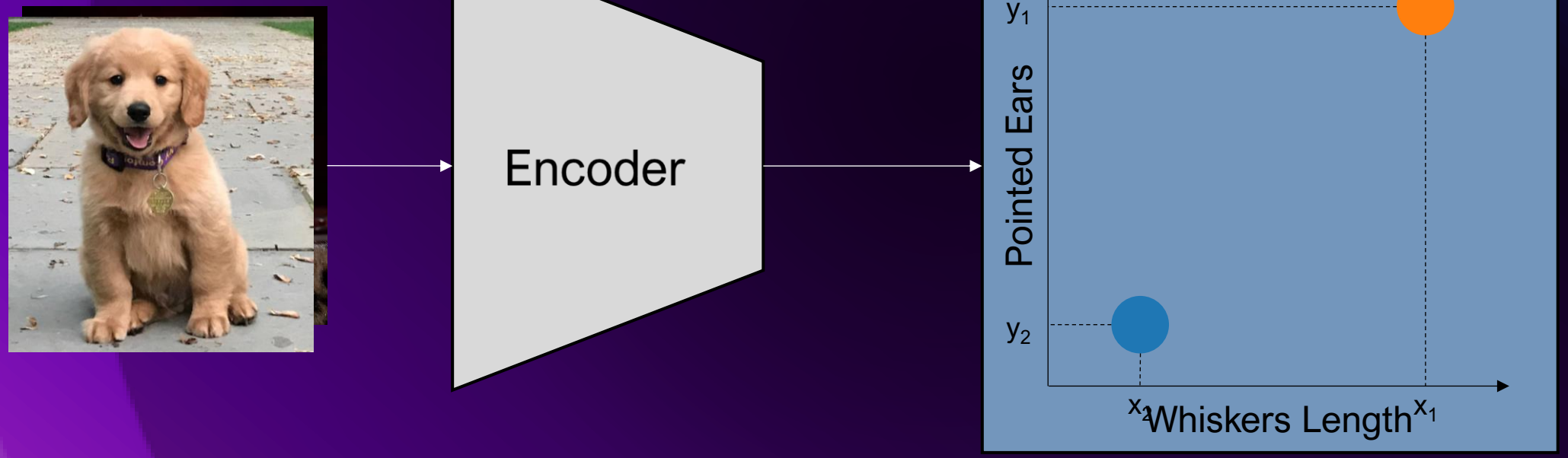


REPRÉSENTATION LATENTE

Encoder

Cat

Dog

ESPACE LATENT

⚠ Cas idéal ⚠

Dataset

Encoder

Cat

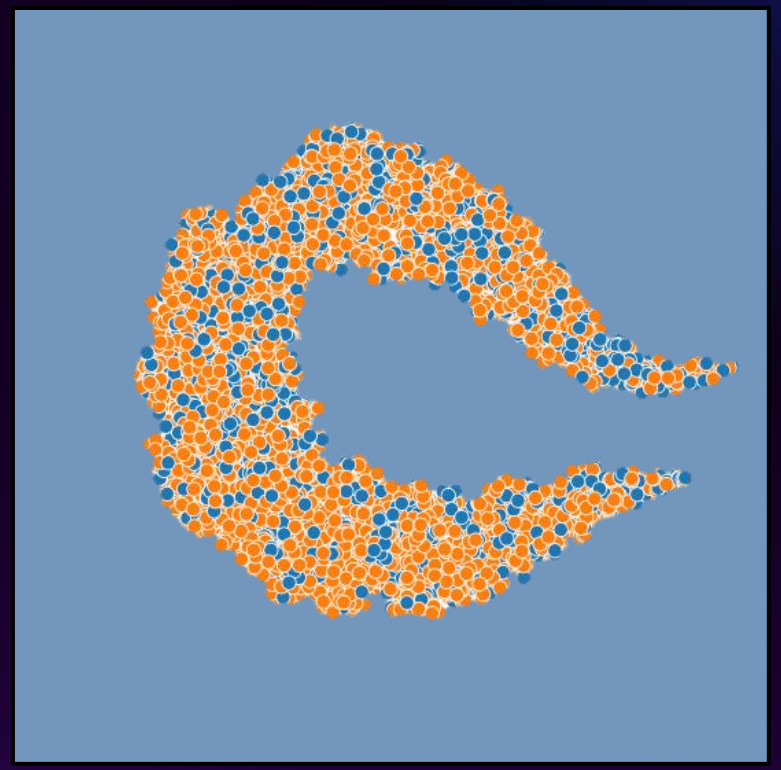
Dog

CAS RÉEL

Apprentissage requis

Dataset

Encoder

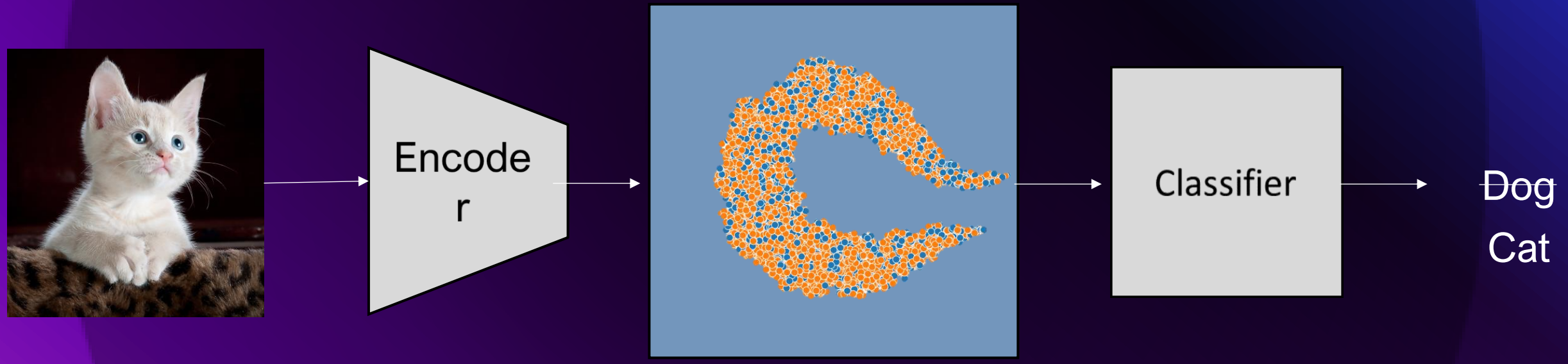


Cat

Dog

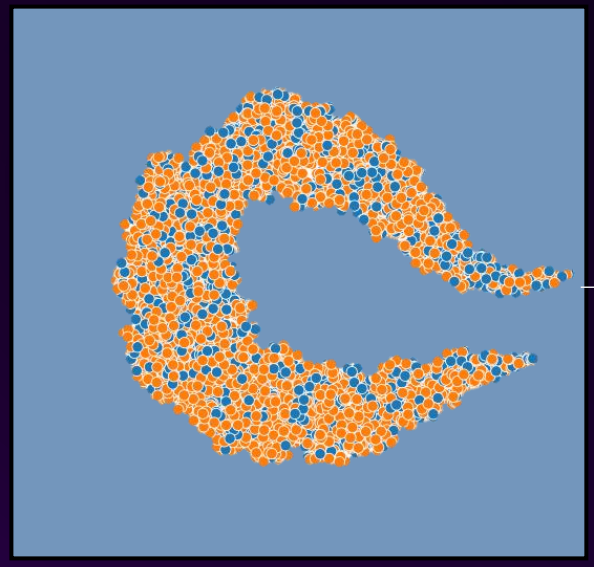
Plus de 2 dimensions

ENTRAÎNEMENT



ENTRAÎNEMENT

Encode
r

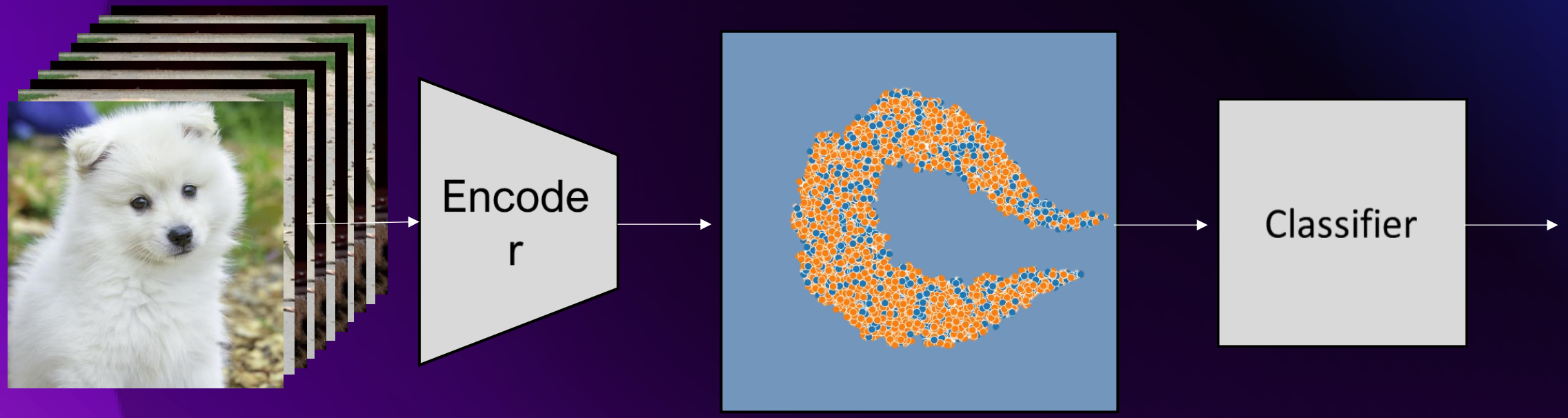


Classifier

~~Cat~~

Dog

ENTRAÎNEMENT



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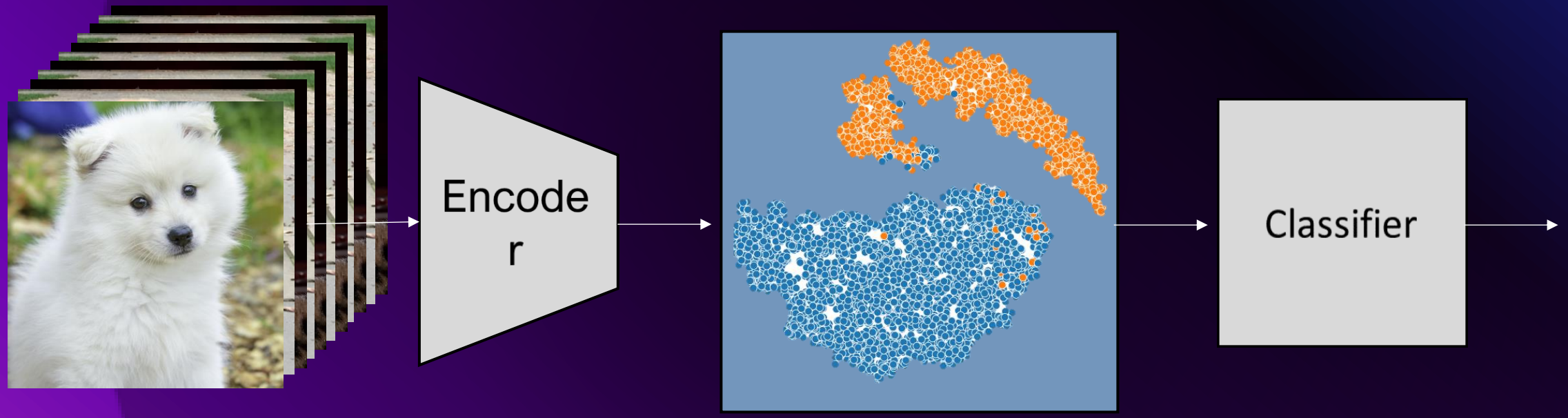
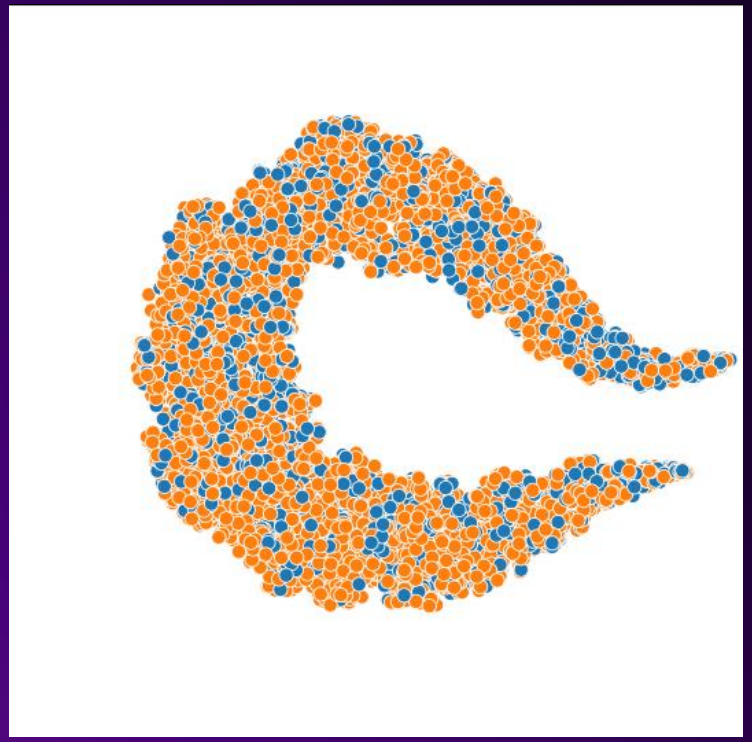
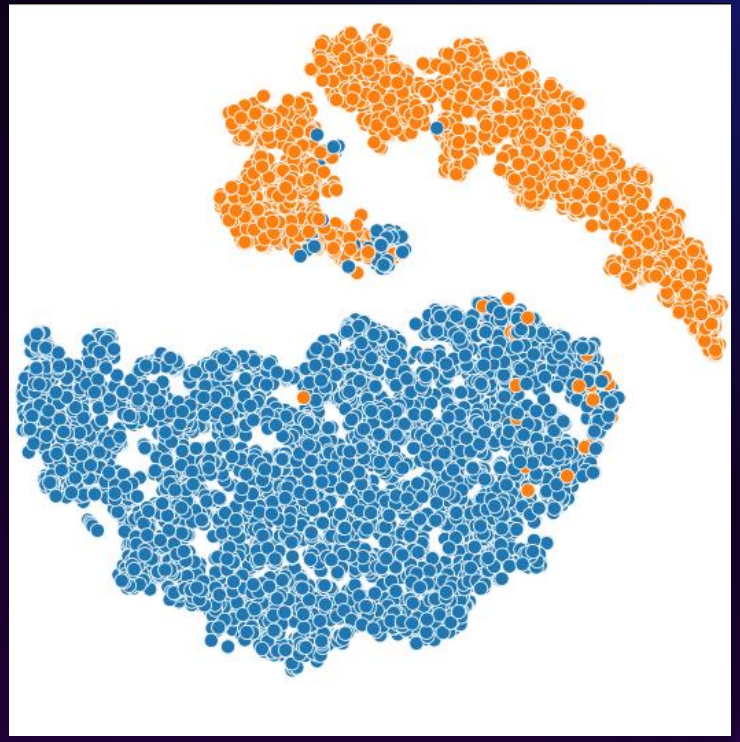


ENTRAÎNEMENT

Espace latent initial



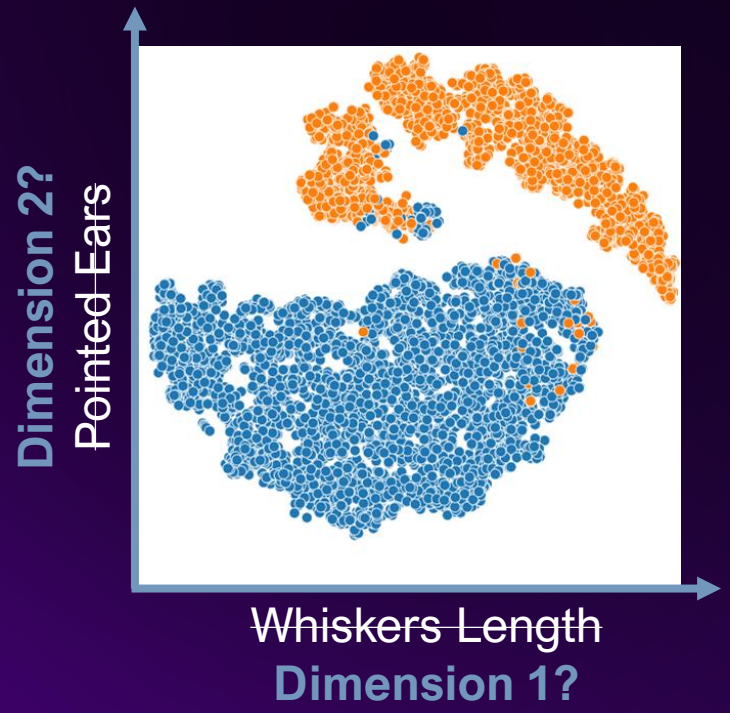
Espace latent optimisé



IA EXPLICABLE

Question de recherche

Comment pouvons-nous exploiter l'espace latent pour mieux comprendre l'influence des caractéristiques d'entrée sur le processus décisionnel ?



PROCESSUS DE DÉCISION HUMAIN

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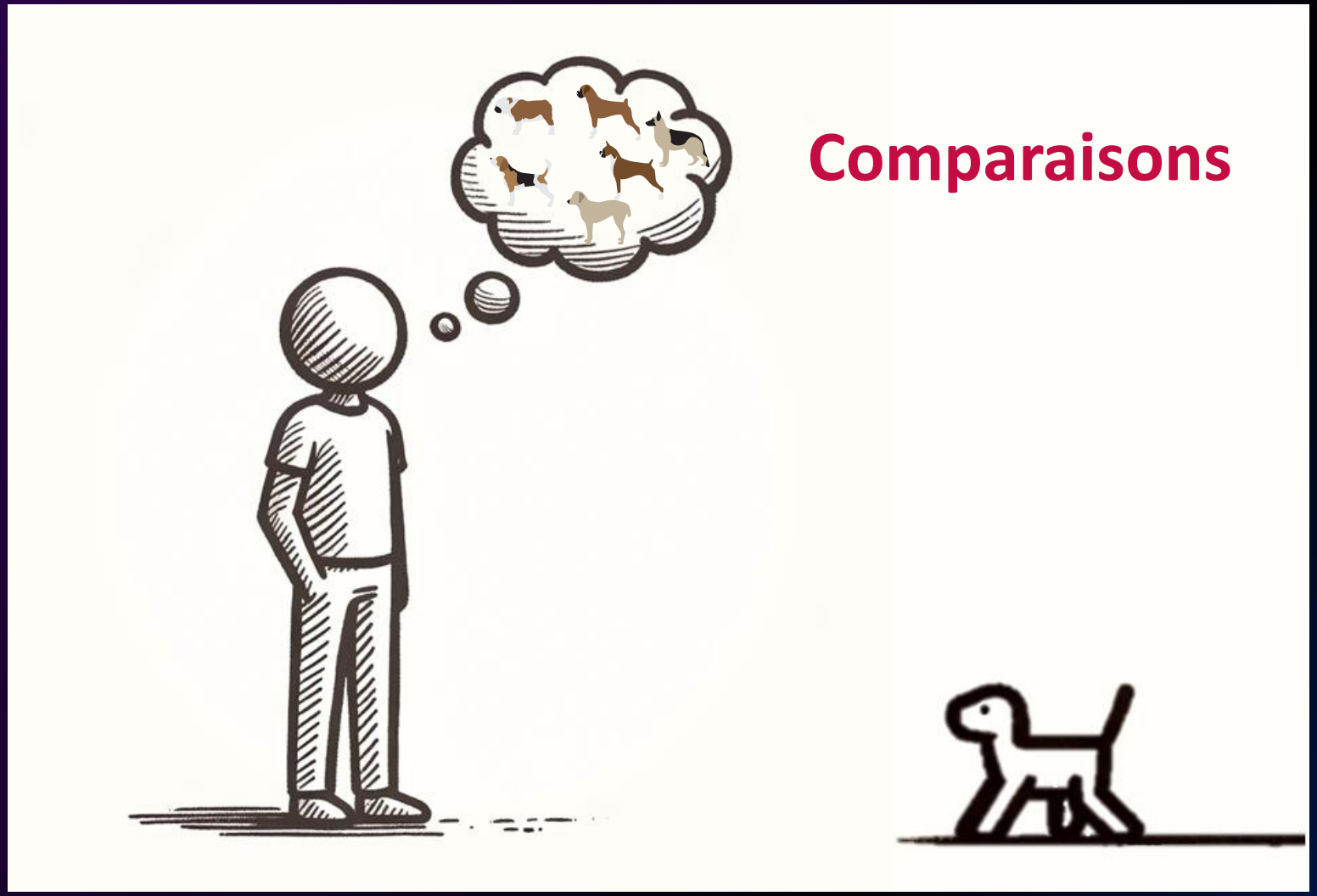
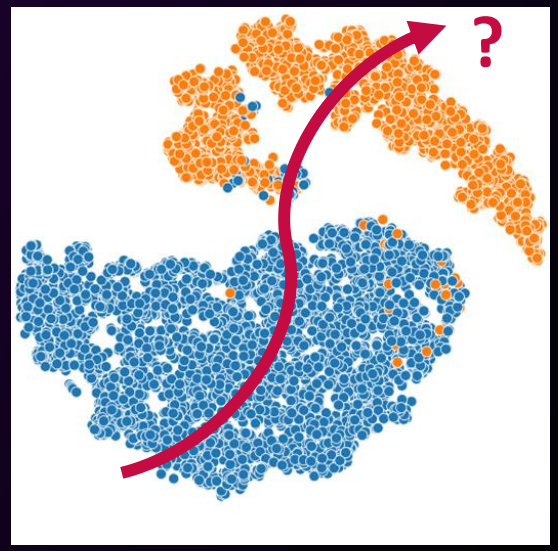


IA EXPLICABLE PAR COMPARAISON

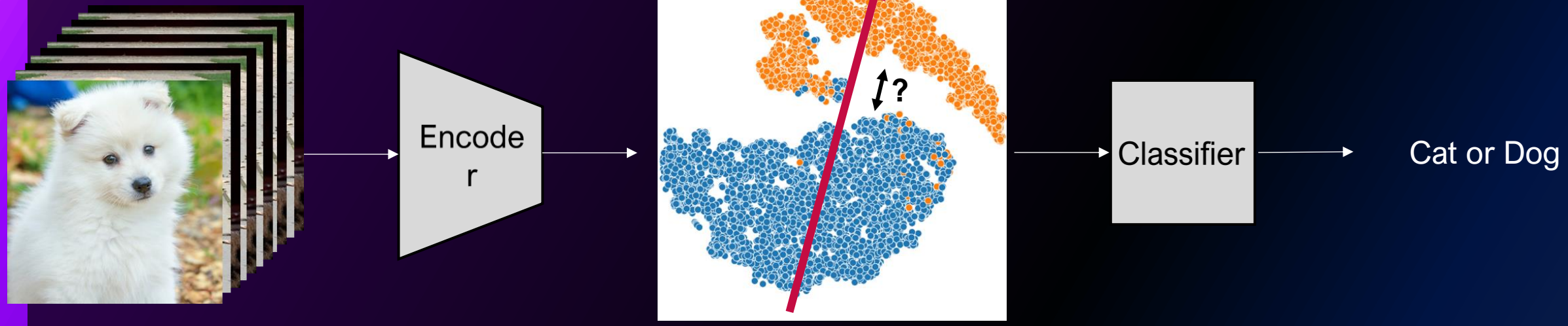
Comment naviguer dans l'espace latent ?



IA EXPLICABLE PAR COMPARAISON

Problème : positions relatives dénuées de sens dans l'espace latent

Solution : contraindre l’espace latent et trier les entrées



Direction discriminante

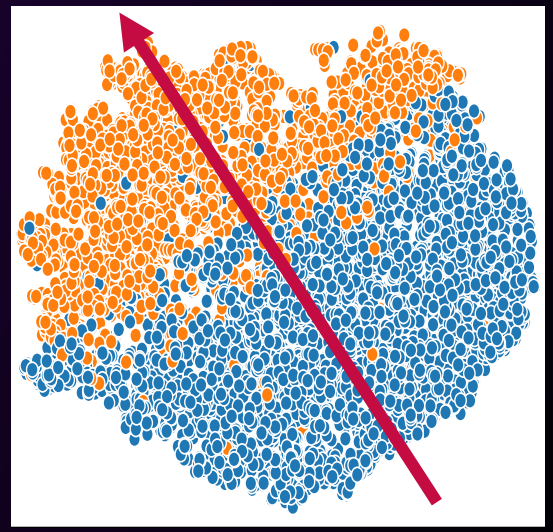
IA EXPLICABLE PAR COMPARAISON

Problème : positions relatives dénuées de sens dans l'espace latent

Solution : contraindre l'espace latent et trier les entrées

Encoder

Espace latent contraint



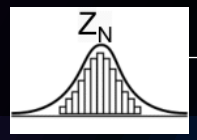
Decoder

Classifier

Cat or Dog

Fake

Real

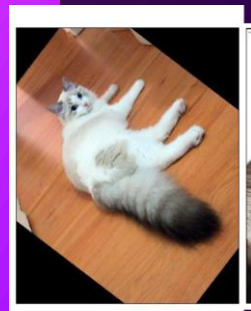
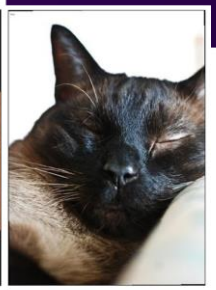


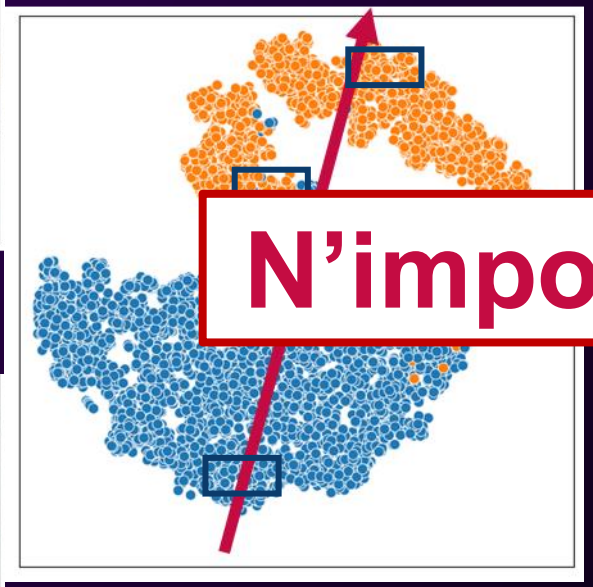
Discriminator

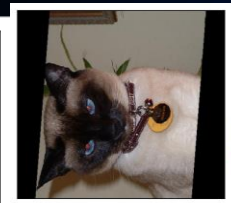
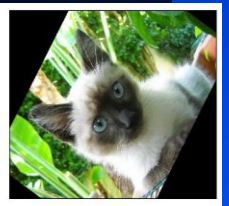
P(real)

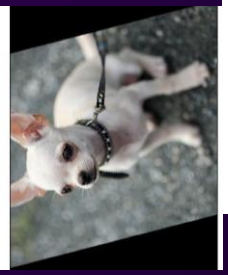
IA EXPLICABLE PAR COMPARAISON

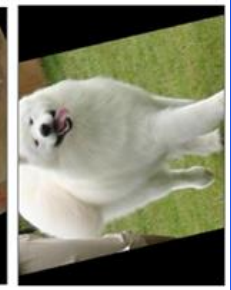
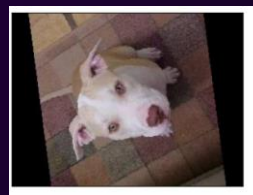
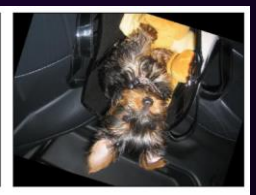


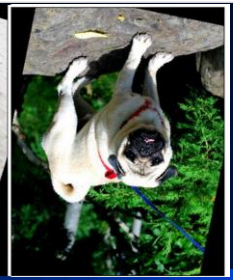










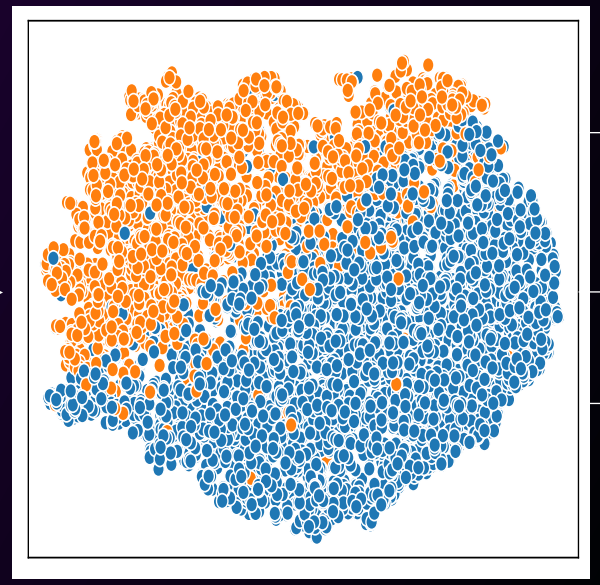
N’importe quel critère !

Dog
Rotation angle ∈ [90°,180°]

C’EST UNE CONFÉRENCE SUR LES CHATS ?

ADAPTATION DU MODÈLE AUX OSA

Encoder



Decoder

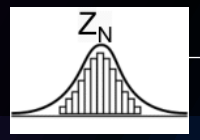
Classifier

Cat or Dog

Fake

Discriminator

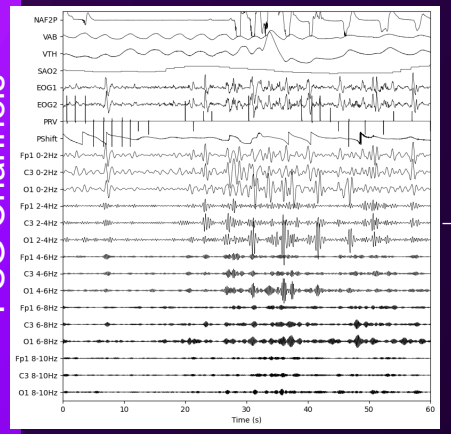
P(real)



Real

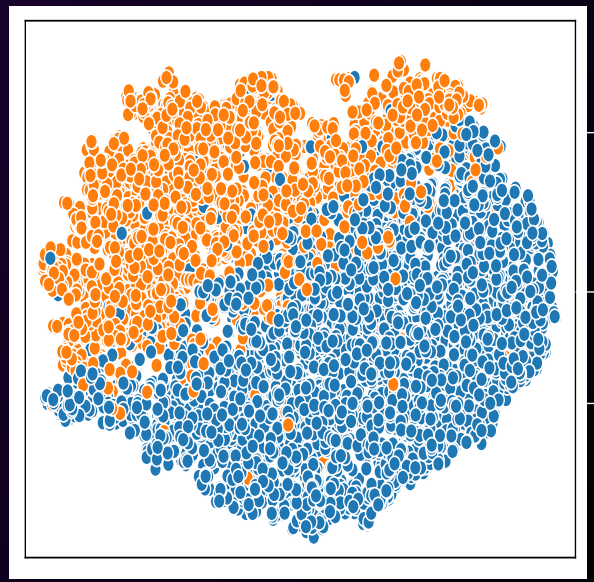
ADAPTATION DU MODÈLE AUX OSA

PSG Channels

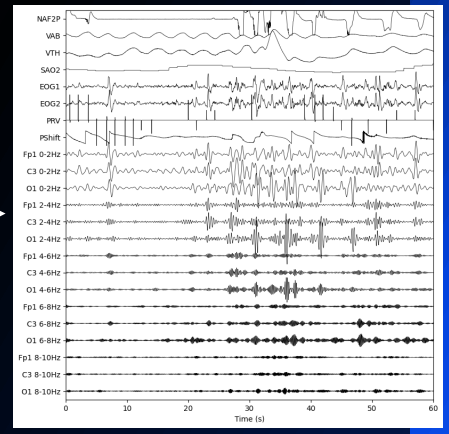


Apnea Event

Encoder



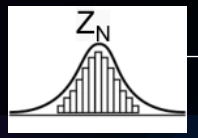
Decoder



Classifier

Fake

Real

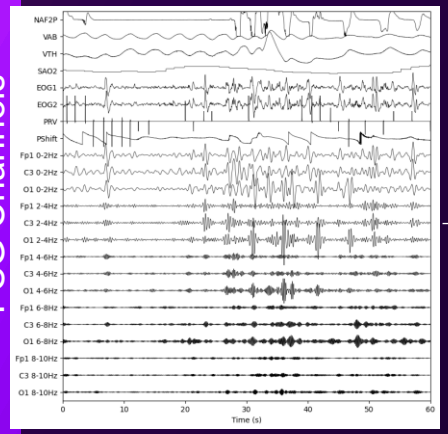


Discriminator

P(real)

ADAPTATION DU MODÈLE AUX OSA

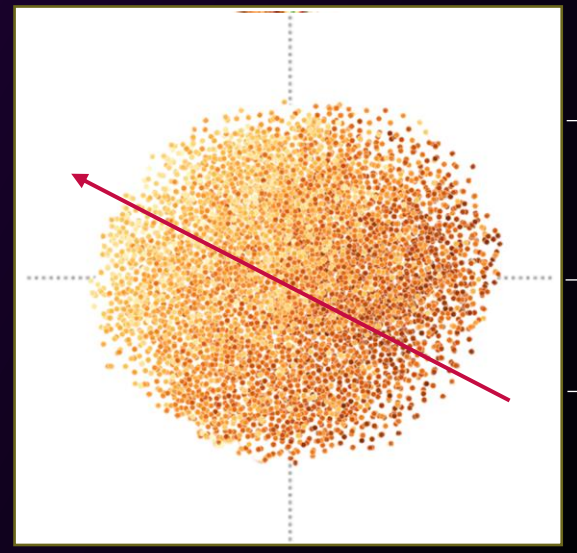
- **Capacité de reconstruction** : explorer de nouvelles caractéristiques
- **Non-parcimonie** : comparaison équitable entre patients et généralisable à de nouveaux patients
- **Classement des événements** : évaluation de la sévérité des apnées fondée sur la comparaison

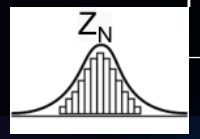


Apnea Event

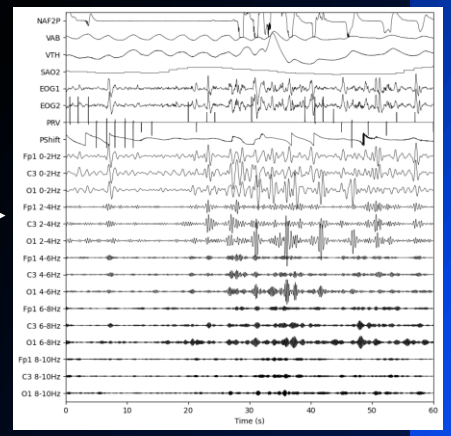
Encoder

severity reference

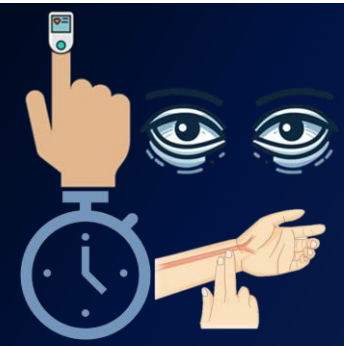




Decoder



Classifier



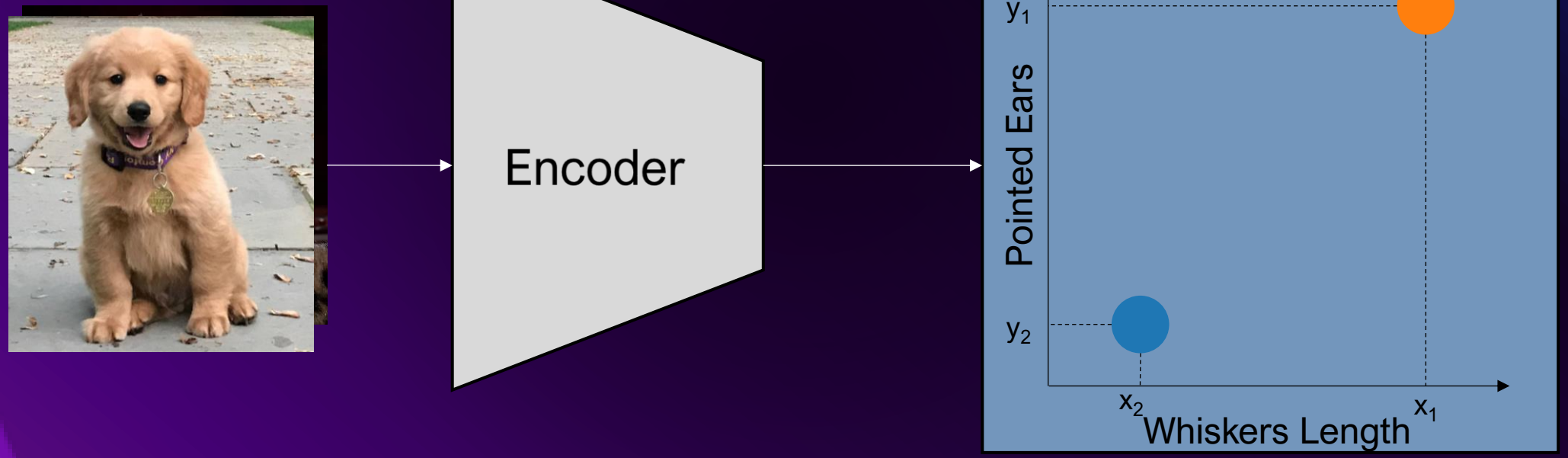
Fake

Real

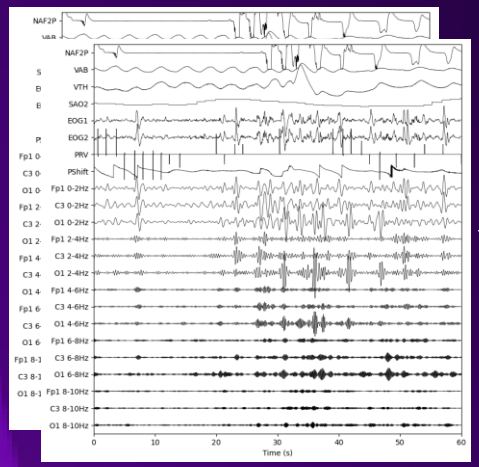
Discriminator

P(real)

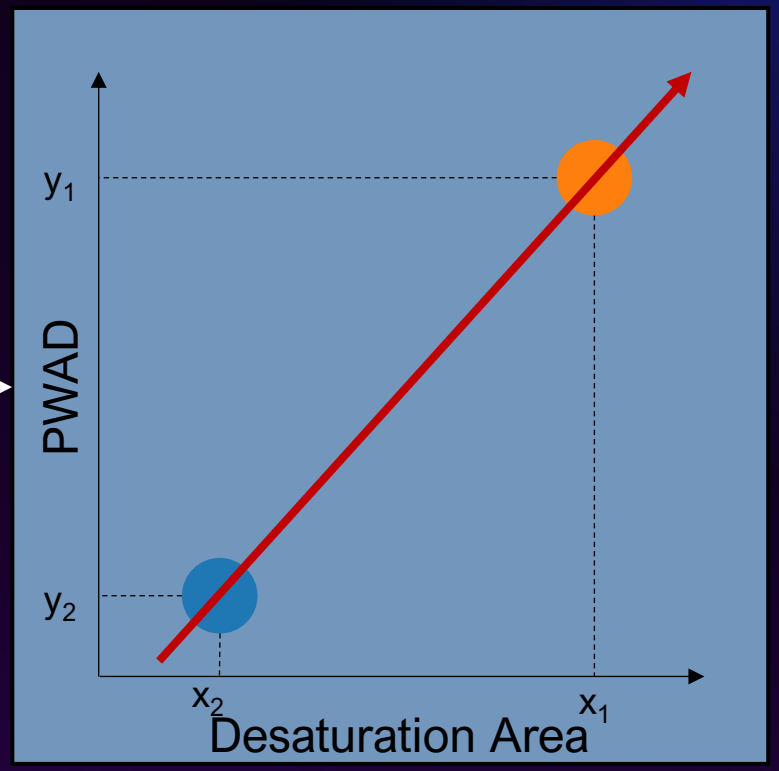
1 MÉTRIQUE DE SÉVÉRITÉ
=
1 DIRECTION



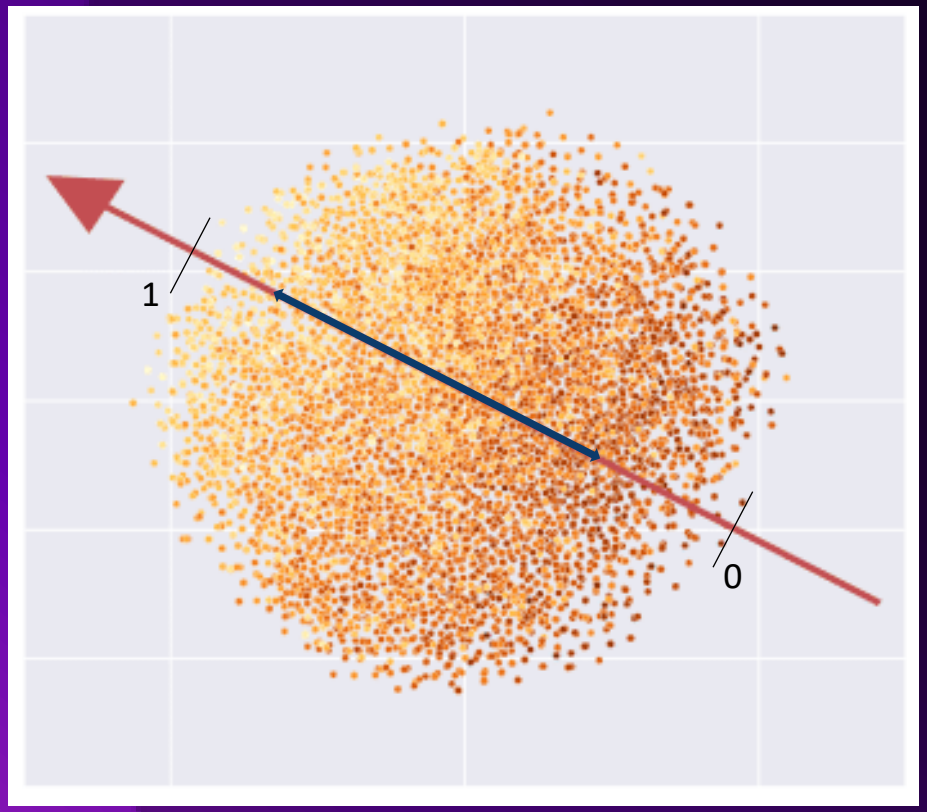
1 MÉTRIQUE DE SÉVÉRITÉ
=
1 DIRECTION

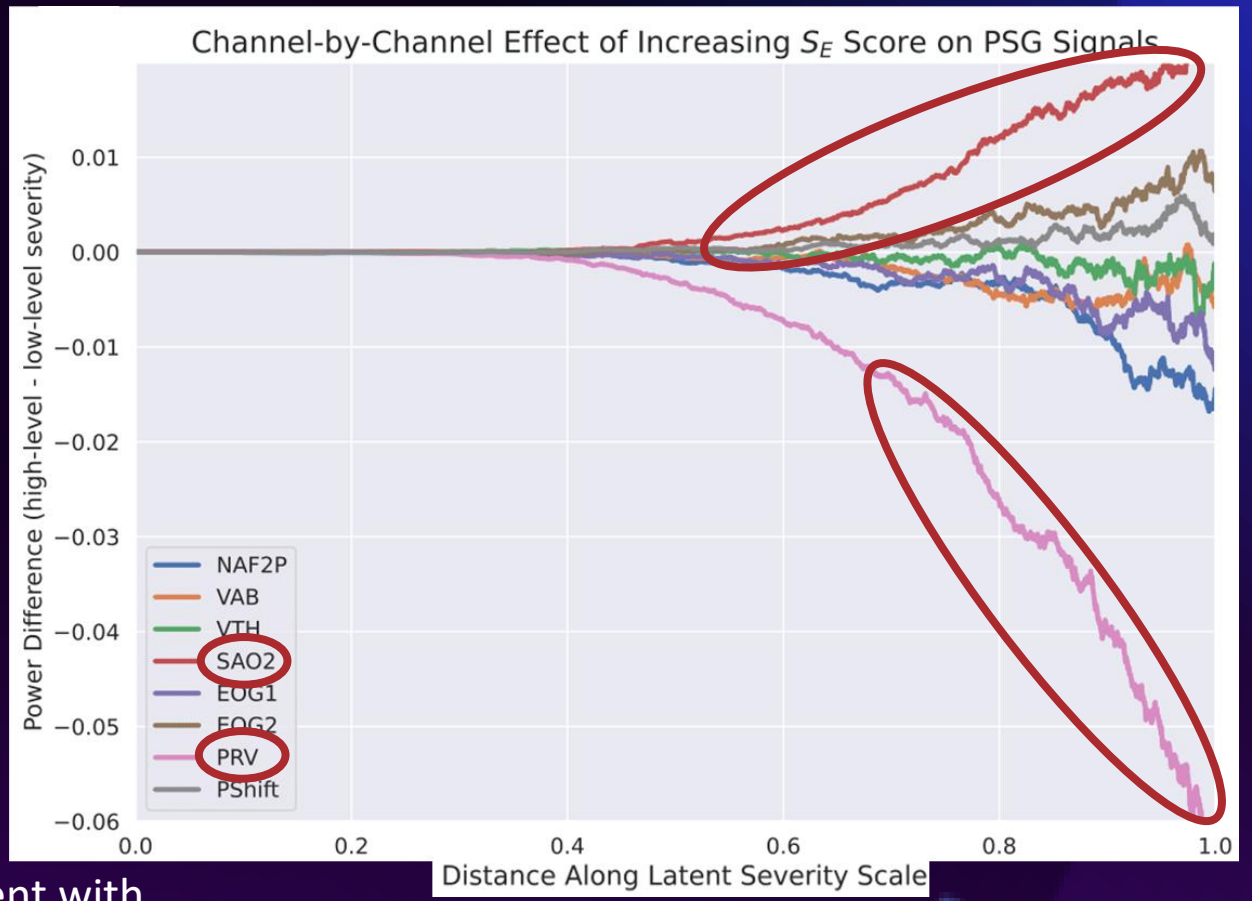


Encoder



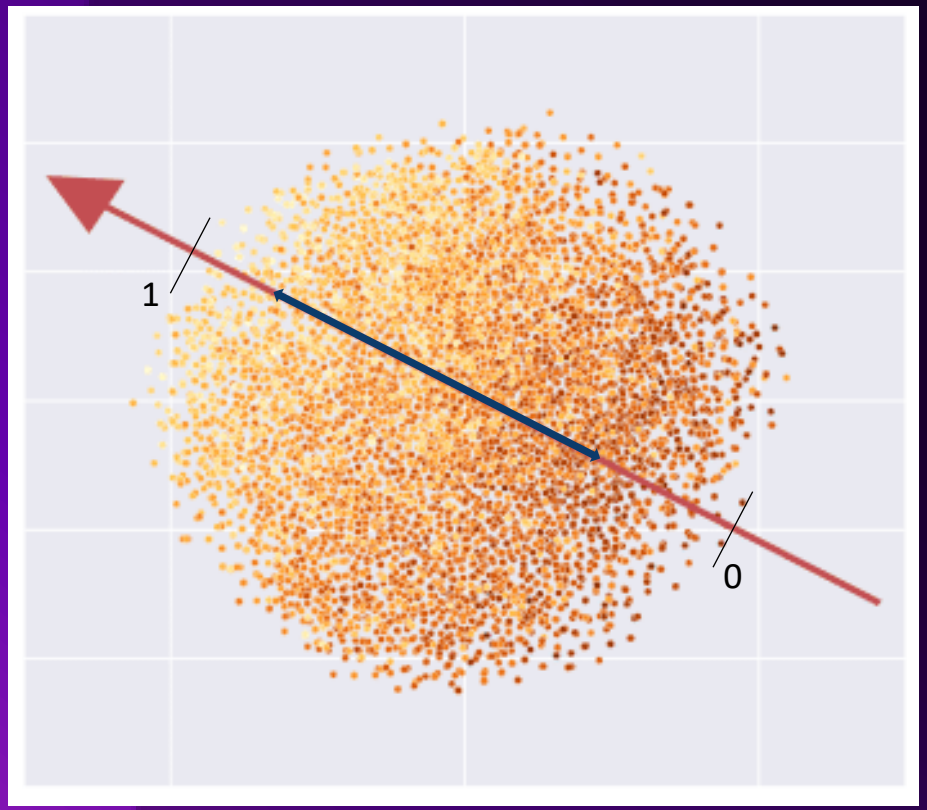
ET ÇA FONCTIONNE ?

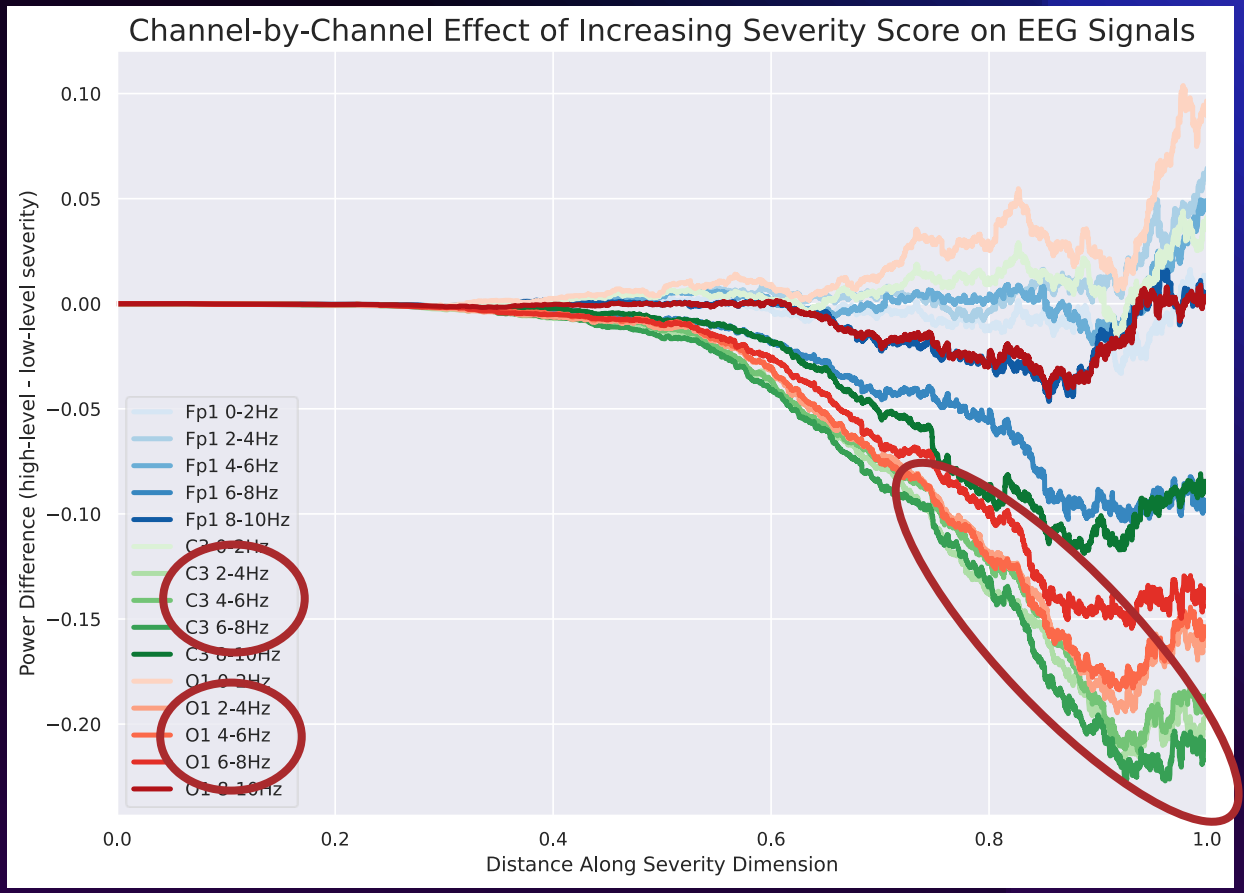




Consistent with
Park *et al.*, 2008 & Kulkas *et al.*, 2013

ET ÇA FONCTIONNE ?



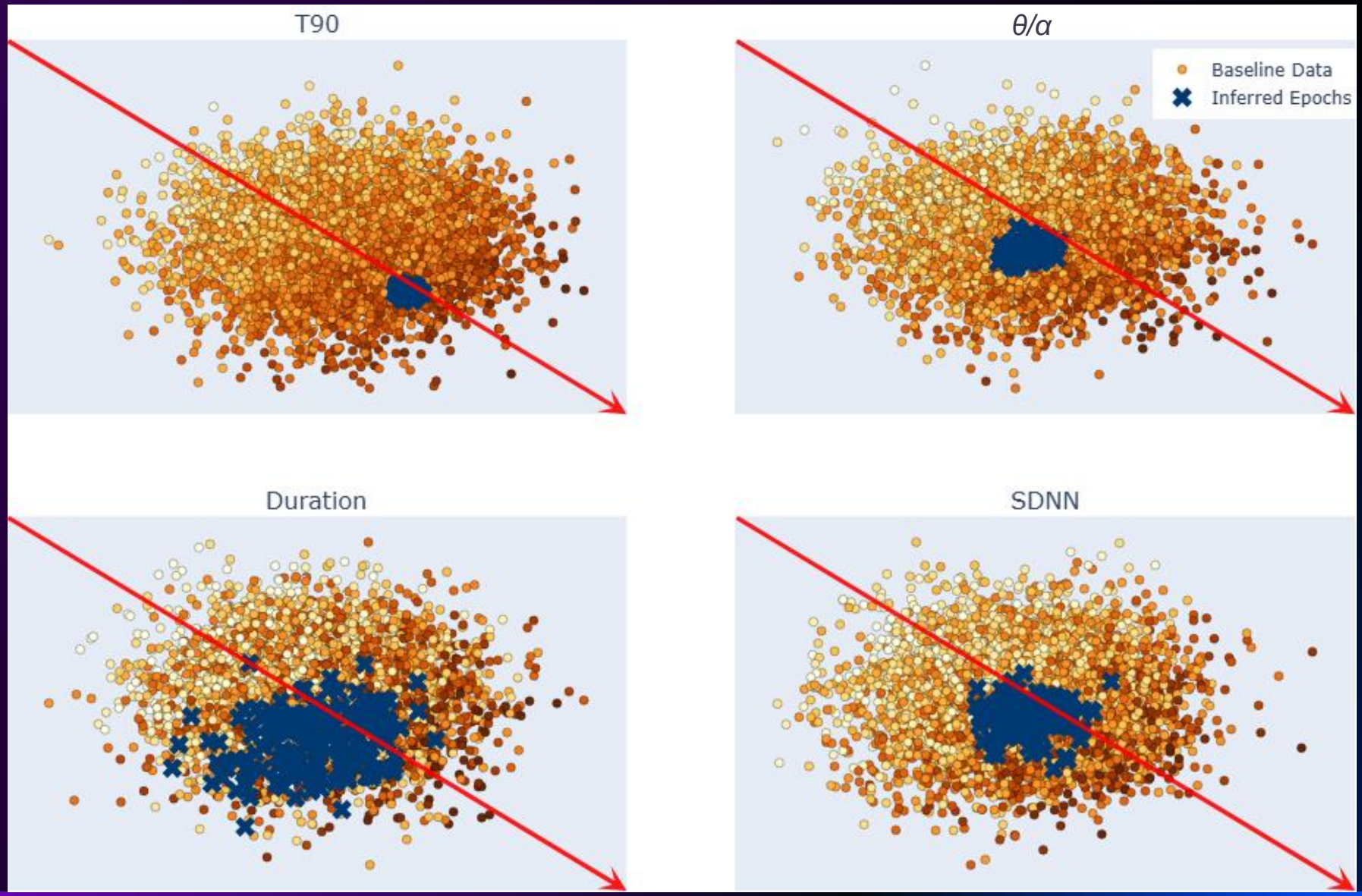


Consistent with
Park *et al.*, 2008 & Kulkas *et al.*, 2013

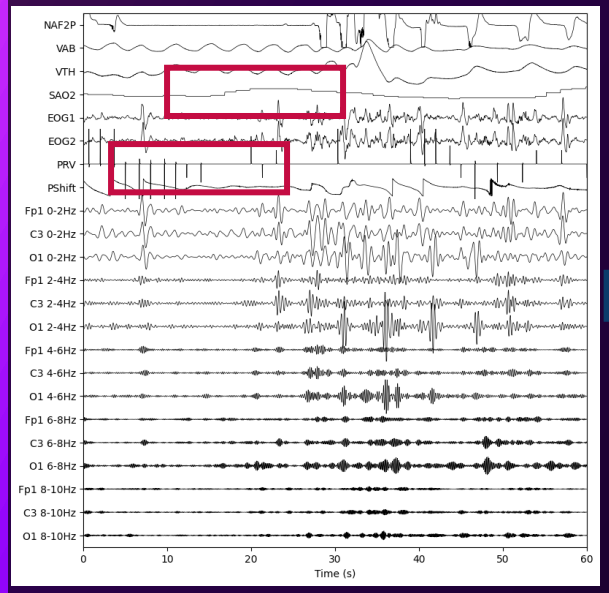
MESSAGE 4

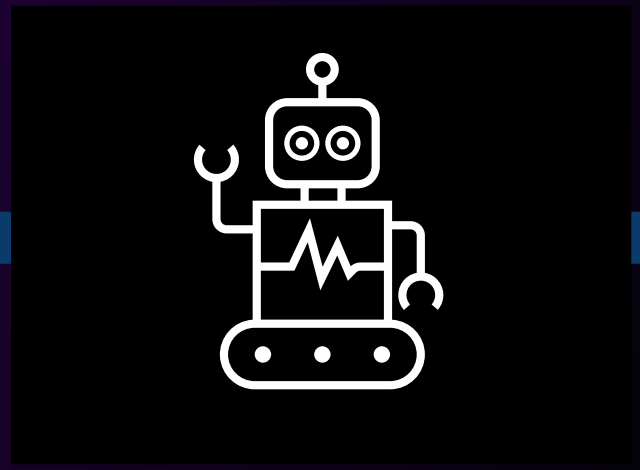
UN SCORE COMPOSITE UNIQUE, MAIS UNE RECHERCHE DE BIOMARQUEUR PERSONNALISÉE

CARTOGRAPHIE PERSONNALISÉE DES BIOMARQUEURS



RÉSUMÉ



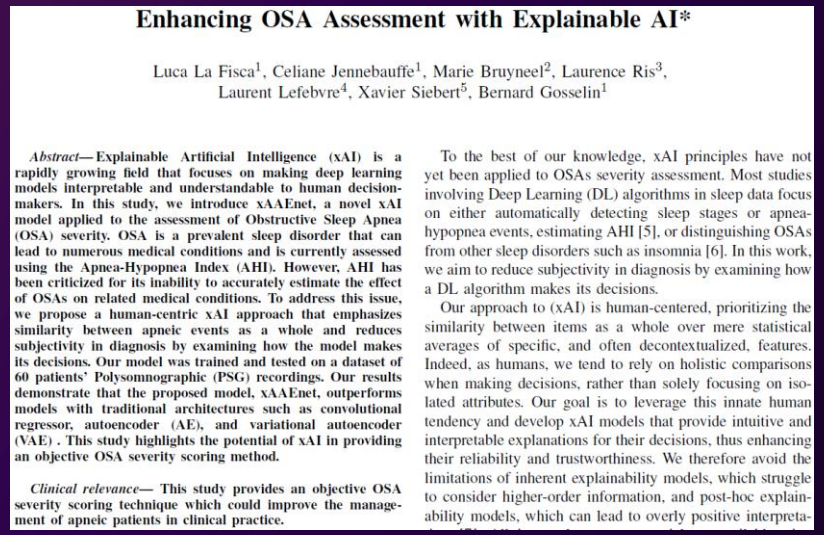


Severity Score

MESSAGE 5

UN OUTIL BIENTÔT À VOTRE DISPOSITION

ÉTAT ACTUEL DU PROJET SLEEPSENSE



Enhancing OSA Assessment with Explainable AI*

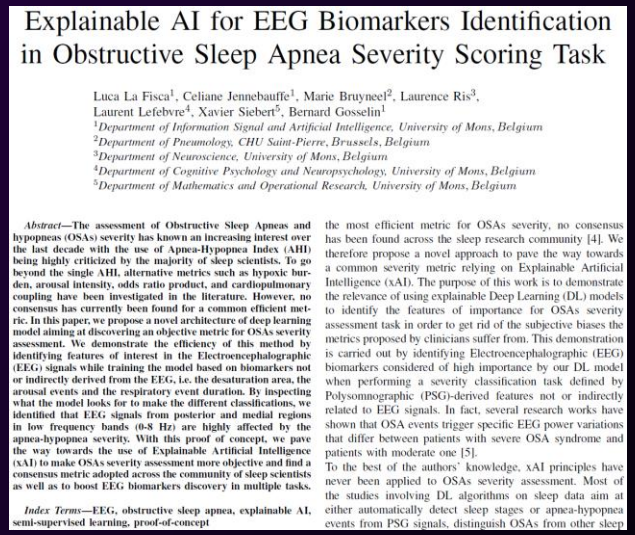
Luca La Fisca[1], Celiane Jennebauffe[1], Marie Bruyneel[2], Laurence Ris[3], Laurent Lefebvre[4], Xavier Siebert[5], Bernard Gosselin[1]

***Abstract*— Explainable Artificial Intelligence (xAI) is a rapidly growing field that focuses on making deep learning models interpretable and understandable to human decision-makers. In this study, we introduce xAAEnet, a novel xAI model applied to the assessment of Obstructive Sleep Apnea (OSA) severity. OSA is a prevalent sleep disorder that can lead to numerous medical conditions and is currently assessed using the Apnea-Hypopnea Index (AHI). However, AHI has been criticized for its inability to accurately estimate the effect of OSAs on related medical conditions. To address this issue, we propose a human-centric xAI approach that emphasizes similarity between apneic events as a whole and reduces subjectivity in diagnosis by examining how the model makes its decisions. Our model was trained and tested on a dataset of 60 patients' Polysomnographic (PSG) recordings. Our results demonstrate that the proposed model, xAAEnet, outperforms models with traditional architectures such as convolutional regressor, autoencoder (AE), and variational autoencoder (VAE) . This study highlights the potential of xAI in providing an objective OSA severity scoring method.**

***Clinical relevance*— This study provides an objective OSA severity scoring technique which could improve the management of apneic patients in clinical practice.**

To the best of our knowledge, xAI principles have not yet been applied to OSAs severity assessment. Most studies involving Deep Learning (DL) algorithms in sleep data focus on either automatically detecting sleep stages or apnea-hypopnea events, estimating AHI [5], or distinguishing OSAs from other sleep disorders such as insomnia [6]. In this work, we aim to reduce subjectivity in diagnosis by examining how a DL algorithm makes its decisions.

Our approach to (xAI) is human-centered, prioritizing the similarity between items as a whole over mere statistical averages of specific, and often decontextualized, features. Indeed, as humans, we tend to rely on holistic comparisons when making decisions, rather than solely focusing on isolated attributes. Our goal is to leverage this innate human tendency and develop xAI models that provide intuitive and interpretable explanations for their decisions, thus enhancing their reliability and trustworthiness. We therefore avoid the limitations of inherent explainability models, which struggle to consider higher-order information, and post-hoc explainability models, which can lead to overly positive interpreta-



Explainable AI for EEG Biomarkers Identification in Obstructive Sleep Apnea Severity Scoring Task

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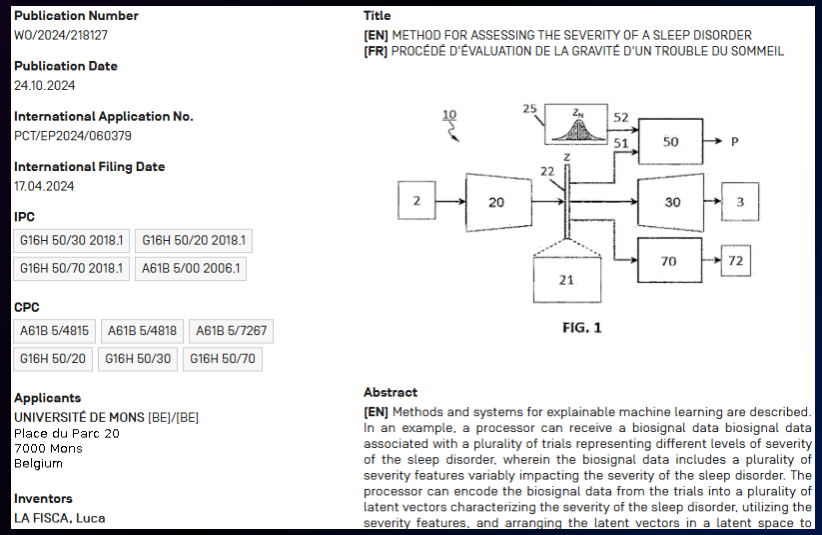
***Abstract*—The assessment of Obstructive Sleep Apneas and hypopneas (OSAs) severity has known an increasing interest over the last decade with the use of Apnea-Hypopnea Index (AHI) being highly criticized by the majority of sleep scientists. To go beyond the single AHI, alternative metrics such as hypoxic burden, arousal intensity, odds ratio product, and cardiopulmonary coupling have been investigated in the literature. However, no consensus has currently been found for a common efficient metric. In this paper, we propose a novel architecture of deep learning model aiming at discovering an objective metric for OSAs severity assessment. We demonstrate the efficiency of this method by identifying features of interest in the Electroencephalographic (EEG) signals while training the model based on biomarkers not or indirectly derived from the EEG, i.e. the desaturation area, the arousal events and the respiratory event duration. By inspecting what the model looks for to make the different classifications, we identified that EEG signals from posterior and medial regions in low frequency bands (0-8 Hz) are highly affected by the apnea-hypopnea severity. With this proof of concept, we pave the way towards the use of Explainable Artificial Intelligence (xAI) to make OSAs severity assessment more objective and find a consensus metric adopted across the community of sleep scientists as well as to boost EEG biomarkers discovery in multiple tasks.**

***Index Terms*—EEG, obstructive sleep apnea, explainable AI, semi-supervised learning, proof-of-concept**

the most efficient metric for OSAs severity, no consensus has been found across the sleep research community [4]. We therefore propose a novel approach to pave the way towards a common severity metric relying on Explainable Artificial Intelligence (xAI). The purpose of this work is to demonstrate the relevance of using explainable Deep Learning (DL) models to identify the features of importance for OSAs severity assessment task in order to get rid of the subjective biases the metrics proposed by clinicians suffer from. This demonstration is carried out by identifying Electroencephalographic (EEG) biomarkers considered of high importance by our DL model when performing a severity classification task defined by Polysomnographic (PSG)-derived features not or indirectly related to EEG signals. In fact, several research works have shown that OSA events trigger specific EEG power variations that differ between patients with severe OSA syndrome and patients with moderate one [5].

To the best of the authors' knowledge, xAI principles have never been applied to OSAs severity assessment. Most of the studies involving DL algorithms on sleep data aim at either automatically detect sleep stages or apnea-hypopnea events from PSG signals, distinguish OSAs from other sleep



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Title
[EN] METHOD FOR ASSESSING THE SEVERITY OF A SLEEP DISORDER
[FR] PROCÉDÉ D'ÉVALUATION DE LA GRAVITÉ D'UN TROUBLE DU SOMMEIL

FIG. 1

Abstract
[EN] Methods and systems for explainable machine learning are described. In an example, a processor can receive a biosignal data biosignal data associated with a plurality of trials representing different levels of severity of the sleep disorder, wherein the biosignal data includes a plurality of severity features variably impacting the severity of the sleep disorder. The processor can encode the biosignal data from the trials into a plurality of latent vectors characterizing the severity of the sleep disorder, utilizing the severity features, and arranging the latent vectors in a latent space to

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REJOIGNEZ L'AVENTURE

Phase I

- Collecte PSG annotées
- Robustesse inter-clinique
- Validation technique
- Pas de données démographiques

Phase II

- Étude clinique
- Participation active (co-auteurs)
- Données démographiques souhaitées
- (optionnel) Étude rétrospective

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Données pseudonymisées

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