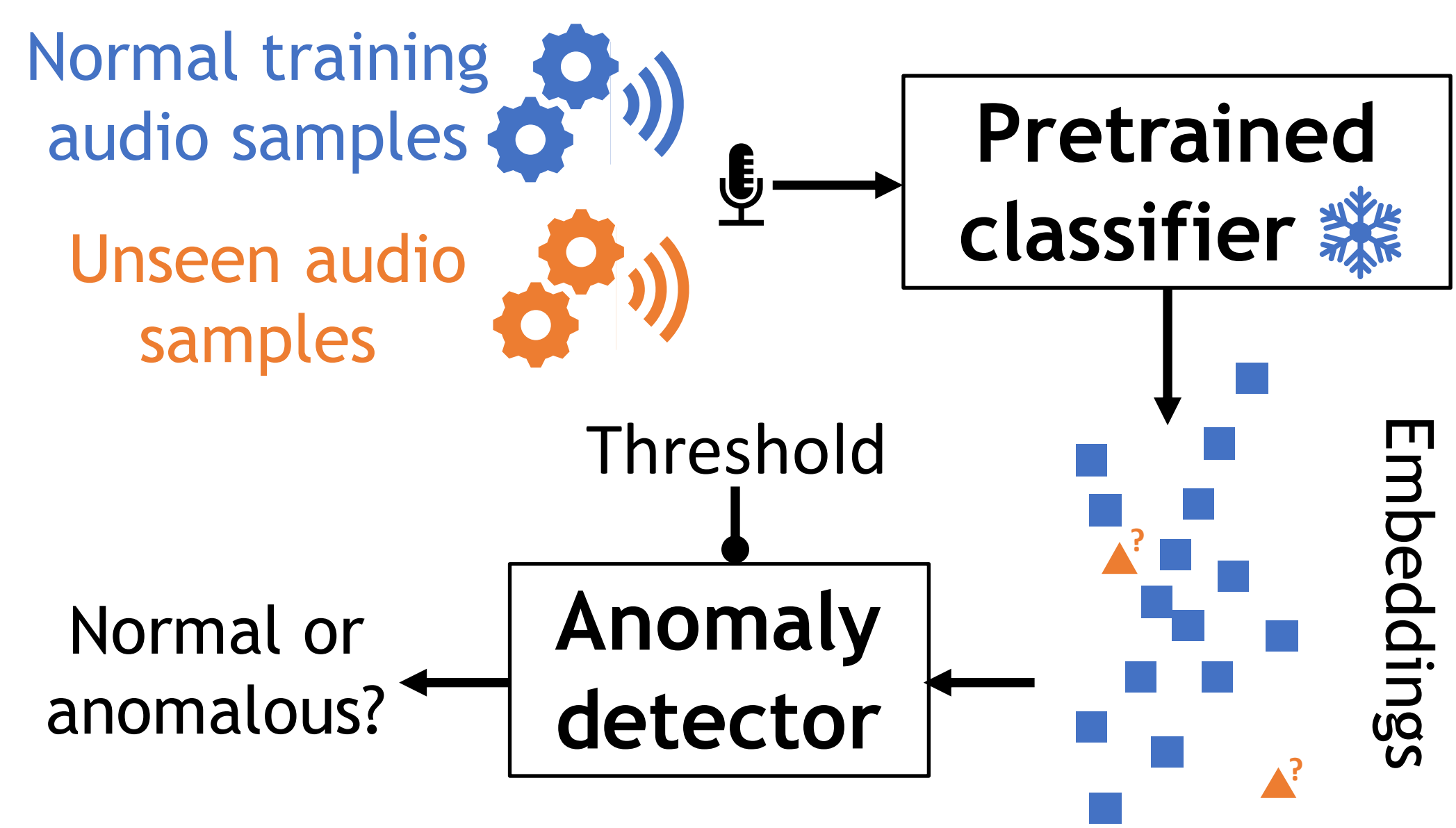


Context

- Automatic anomaly detection brings crucial benefits to modern industries
- Audio allows to perform such detection without line of sight
- Collecting anomalous samples can be difficult to impossible, making unsupervised approaches appealing

Surrogate-task methods

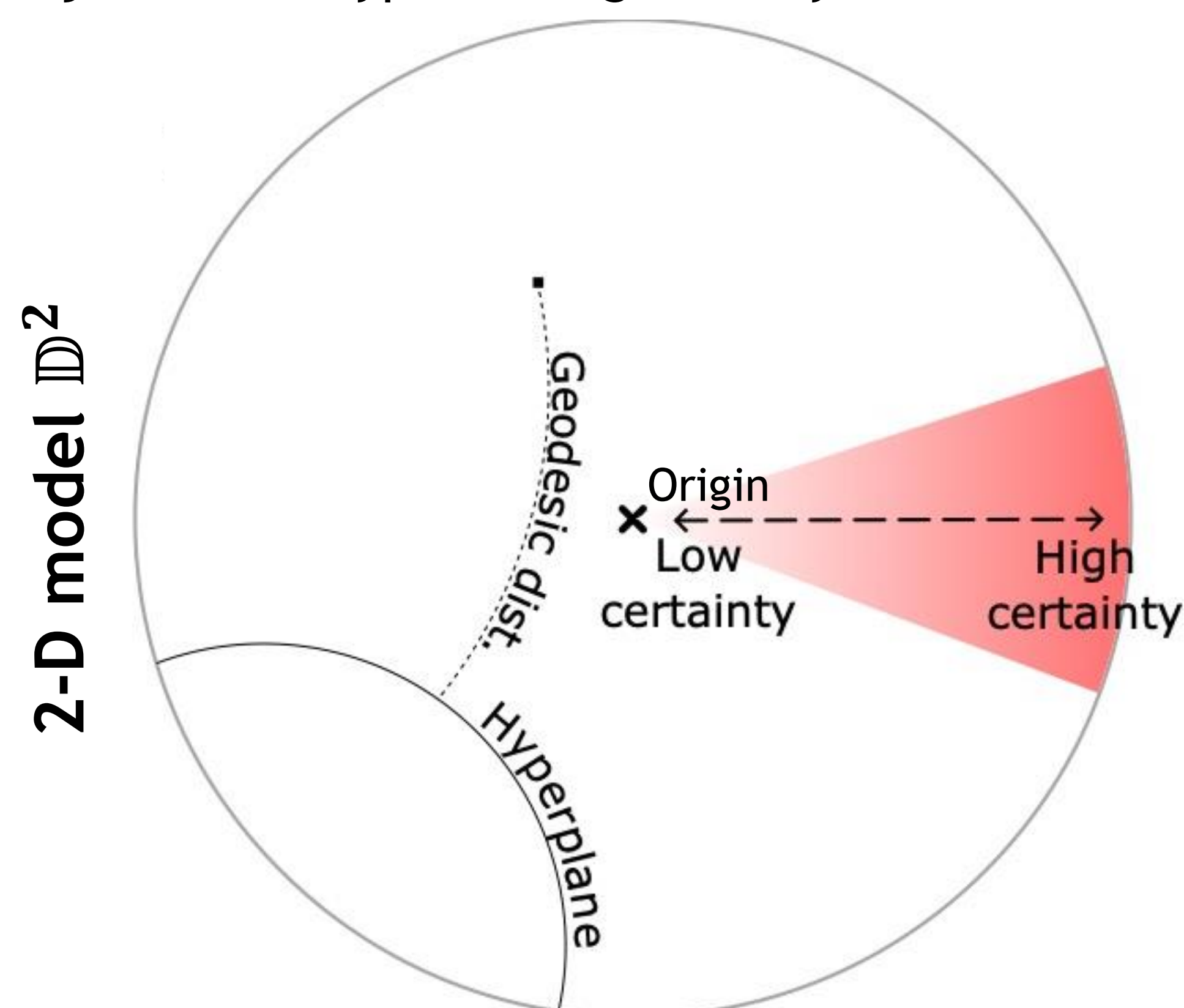
- Find a surrogate classification task for the normal data (e.g., model, speed)
- Train the corresponding classifier
- Use the representations (embeddings) learned by the classifier to determine the condition of unseen data.



Hyperbolic representation

Poincaré ball \mathbb{D}^L model

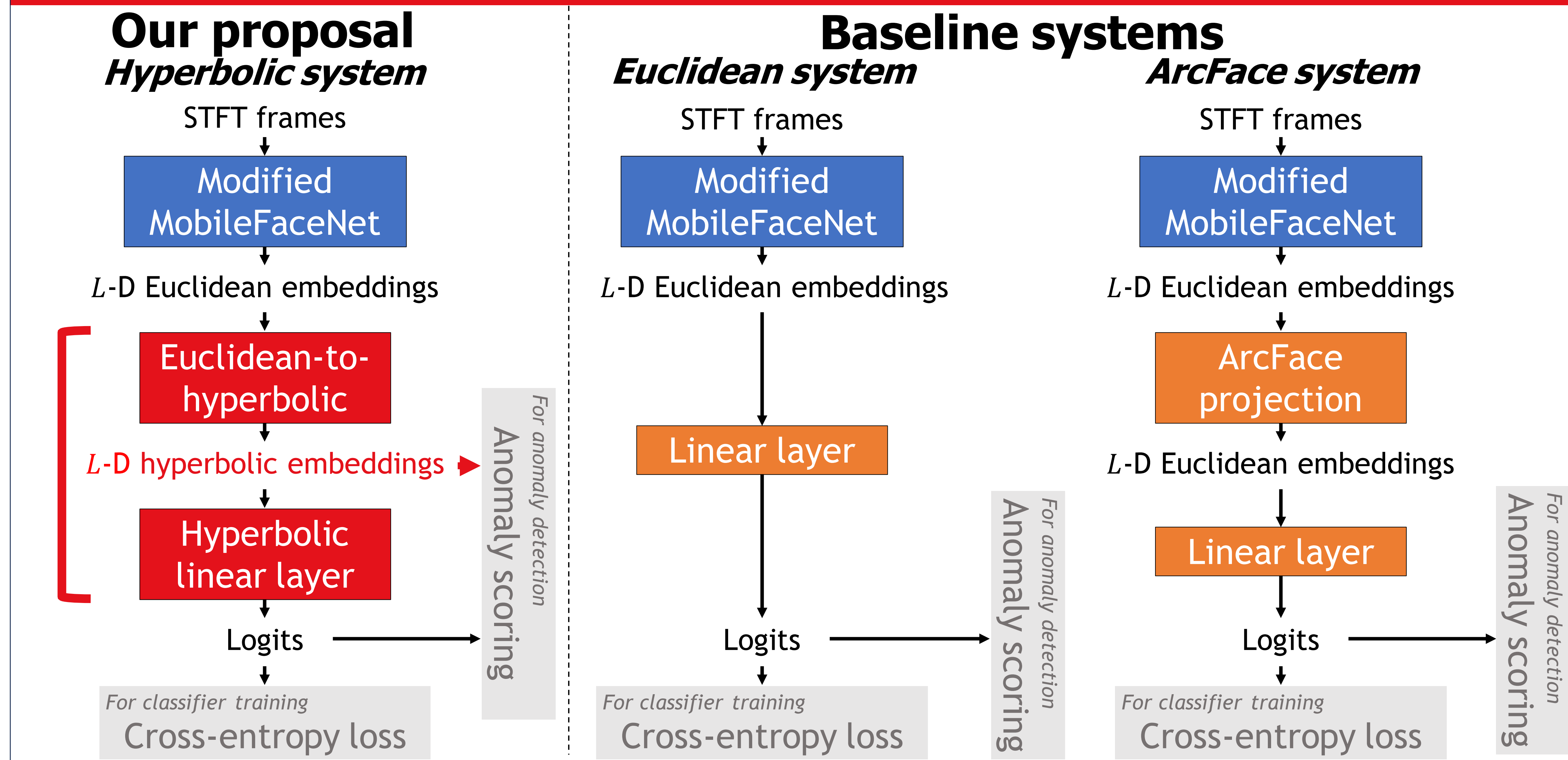
⇒ projection of hyperbolic geometry on Euclidean ball



Hyperbolic geometry:

- Naturally encode tree data, i.e., *hierarchical relationships*
- Naturally encode *classification confidence* as distance to the origin
⇒ *Hyperbolic embeddings could advantageously replace Euclidean embeddings for anomaly detection*

Model & baselines



Results (DCASE 2022)

Anomaly scores

- DCASE logit gap: $\mathcal{A}(\mathbf{x}) = \frac{1}{K} \sum_{k=1}^K \log \left(\frac{1 - \psi_t(\mathbf{x}_k)}{\psi_t(\mathbf{x}_k)} \right)$
- Dist. to origin: $\mathcal{A}_*(\mathbf{x}) = -\frac{1}{K} \sum_{k=1}^K d_{\mathbb{D}}(\mathbf{0}, \mathbf{x}_k)$
- **Ensemble:** $\mathcal{A}_{\text{ens}}(\mathbf{x}) = (1 - w) \times \text{sigmoid}(\mathcal{A}(\mathbf{x})) + w \times (1 + \tanh(\mathcal{A}_*(\mathbf{x})))$
(weights w optimized at validation)

L	System	AUC (S)	AUC (T)	pAUC	Overall
1280	DCASE ST	59.1	47.5	53.6	53.0
—	DCASE AE	64.5	45.2	52.9	53.1
2	Hyperbolic	66.8	58.8	58.0	60.9
	Hyperbolic*	61.3	56.0	58.6	58.6
	Ensemble	66.3	61.5	58.7	62.0
	Euclidean	62.9	59.9	57.6	60.0
	ArcFace	59.7	52.5	55.3	55.7
128	Hyperbolic	66.0	54.1	57.9	58.9
	Euclidean	65.6	60.2	59.8	61.7
	ArcFace	65.6	58.1	59.3	60.8

Evaluation Metrics

L	System	Score	ToyCar	ToyTrain	Bearing	Fan	Gearbox	Slider	Valve	AUC (S)	AUC (T)	pAUC	Overall
2	Hyperbolic	\mathcal{A}	60.1	57.0	61.9	71.2	70.2	81.6	80.2	68.9	71.1	63.6	67.7
	Hyperbolic*	\mathcal{A}_*	48.2	55.1	57.7	66.3	61.4	79.3	83.4	62.7	63.8	60.7	62.4
	Ensemble	\mathcal{A}_{ens}	60.1	57.0	61.9	71.4	70.4	83.0	83.5	69.0	71.9	64.3	68.2
	(weights w)	—	(0.0)	(0.0)	(0.0)	(0.4)	(0.4)	(0.1)	(0.9)	—	—	—	—
	Euclidean	\mathcal{A}	59.2	50.6	64.4	65.8	72.6	77.4	75.7	66.0	69.2	61.1	65.2
	ArcFace	\mathcal{A}	58.9	57.9	61.4	60.6	62.9	78.0	78.7	68.9	63.0	62.1	64.5
128	Hyperbolic	\mathcal{A}	60.8	54.6	68.8	67.3	75.2	82.1	83.4	72.2	69.7	65.1	68.9
	Euclidean	\mathcal{A}	58.6	54.4	73.0	63.2	71.8	83.3	80.1	70.4	69.4	63.7	67.7
	ArcFace	\mathcal{A}	56.2	56.3	73.5	69.8	69.6	82.6	84.2	70.9	71.1	64.6	68.7

Validation Metrics

