COMMUNICATION UNIVERSITY OF CHINA

MCC 媒体融合与传播国家重点实验室
State Key Laboratory of Media Convergence and Communication

Locality-aware Attention Network with Discriminative Dynamics Learning For Weakly Supervised Anomaly Detection

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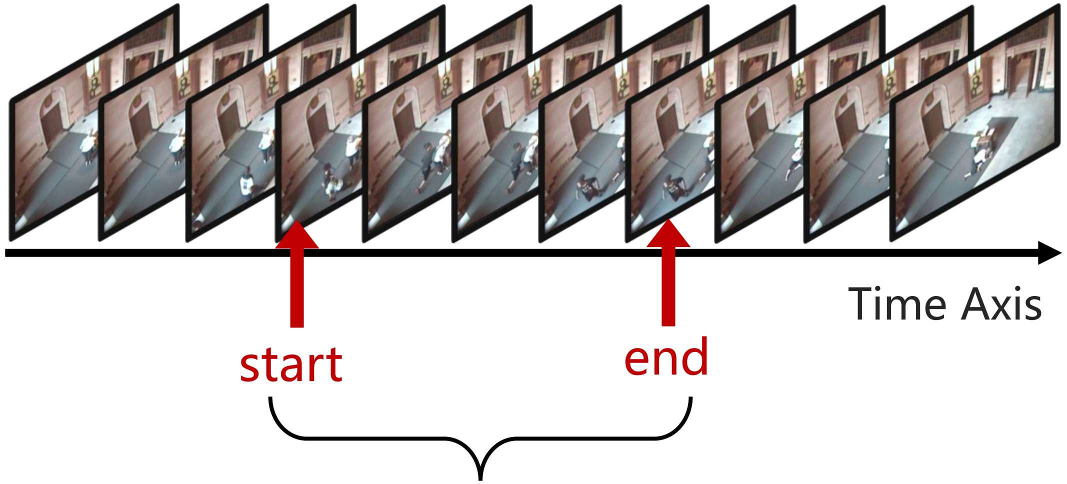
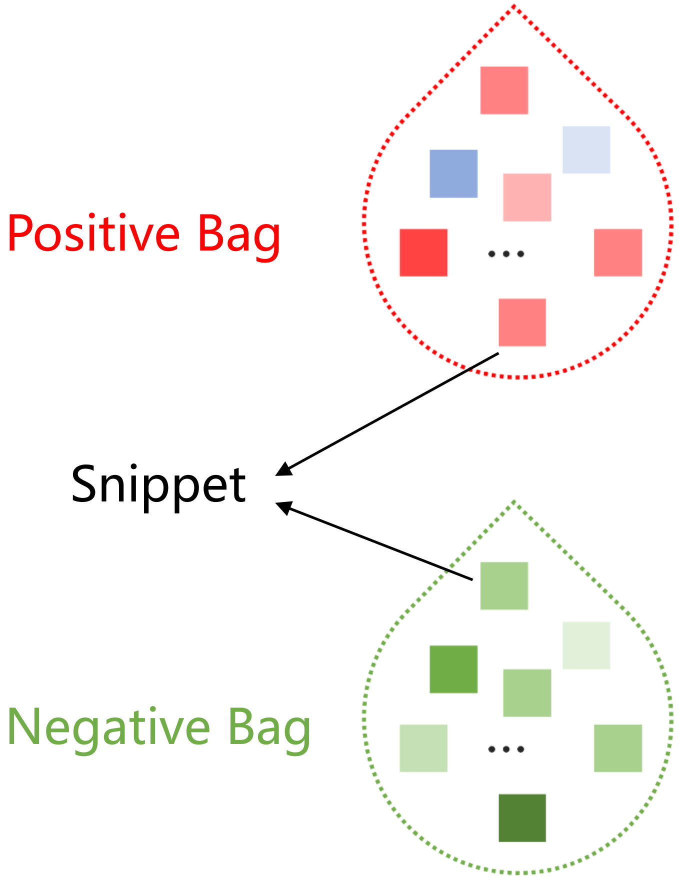
Introduction

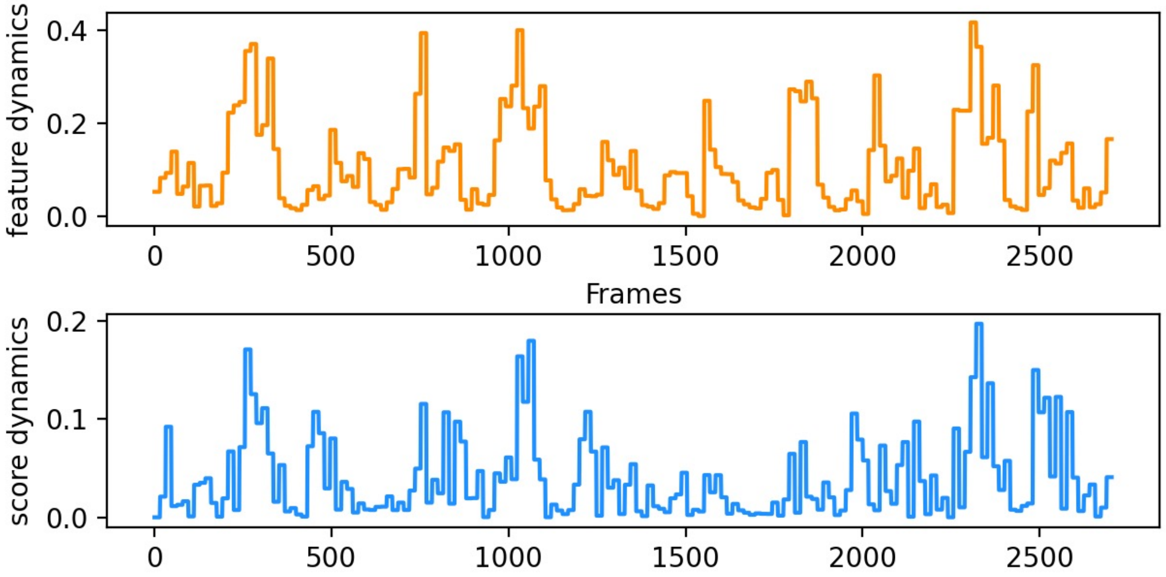
Video Anomaly Detection



locating the start and end of the event at the frame level



Motivation



Temporal Dynamics

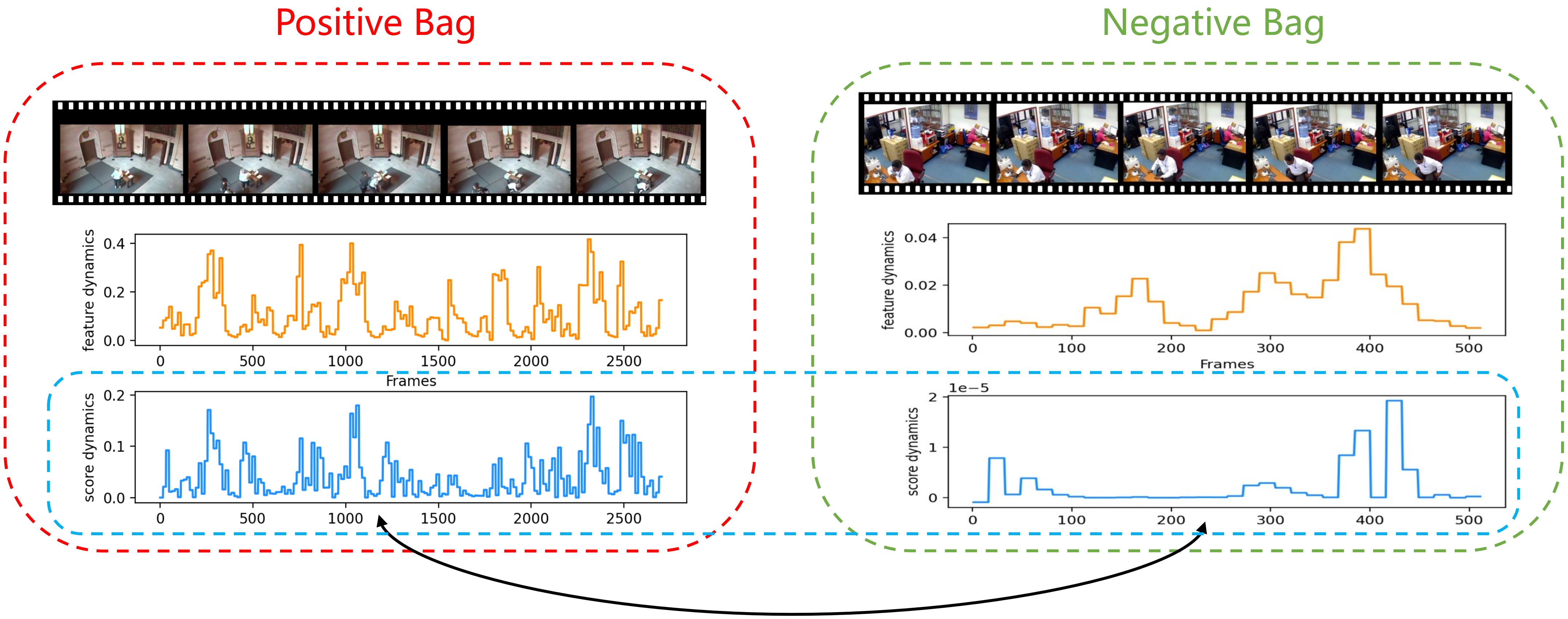
- **Feature Dynamics (FD)**

Feature Difference between adjacent snippet

- **Score Dynamics (SD)**

Score Difference between adjacent snippet

Motivation

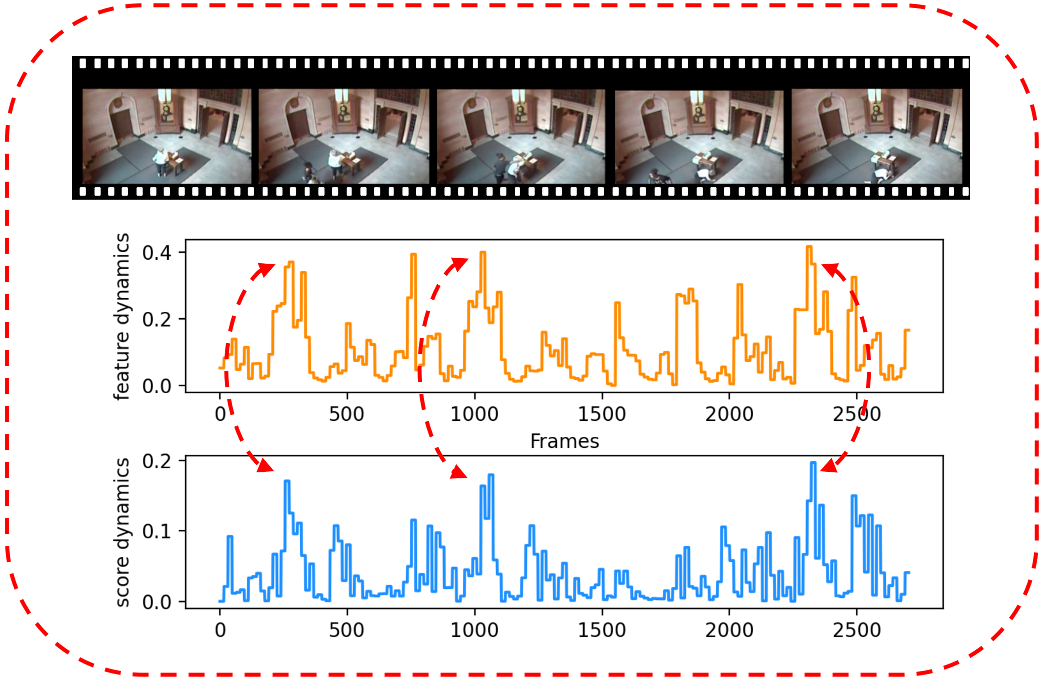


SD in Positive Bag ≫ **SD** in Negative Bag

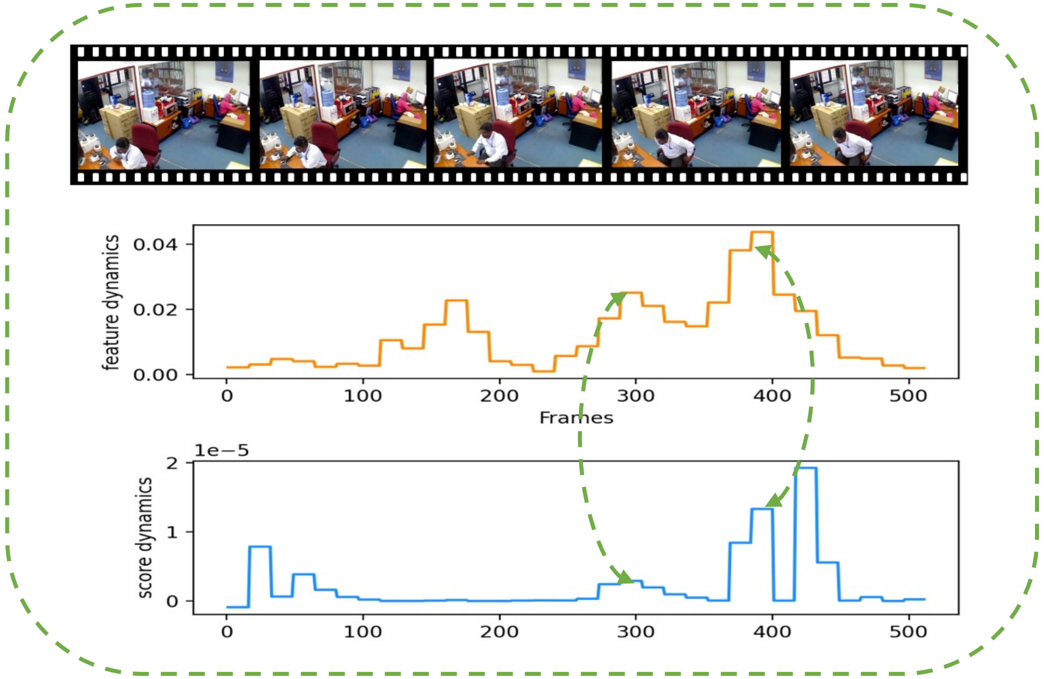
Score Dynamics Ranking $\mathcal{L}_{DR}$

Motivation

Positive Bag



Negative Bag

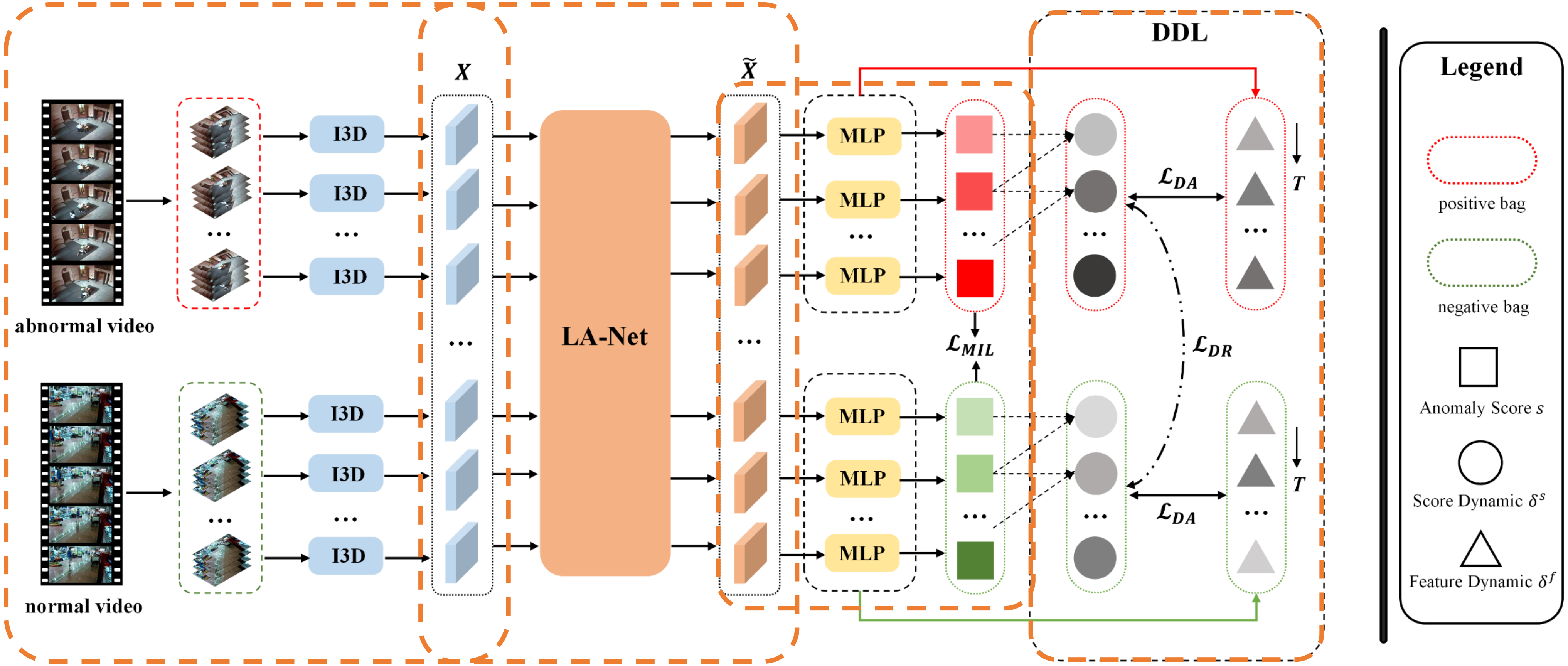


The **FD** and **SD** within a bag show a certain temporal consistency

Feature Dynamics Alignment $\mathcal{L}_{DA}$

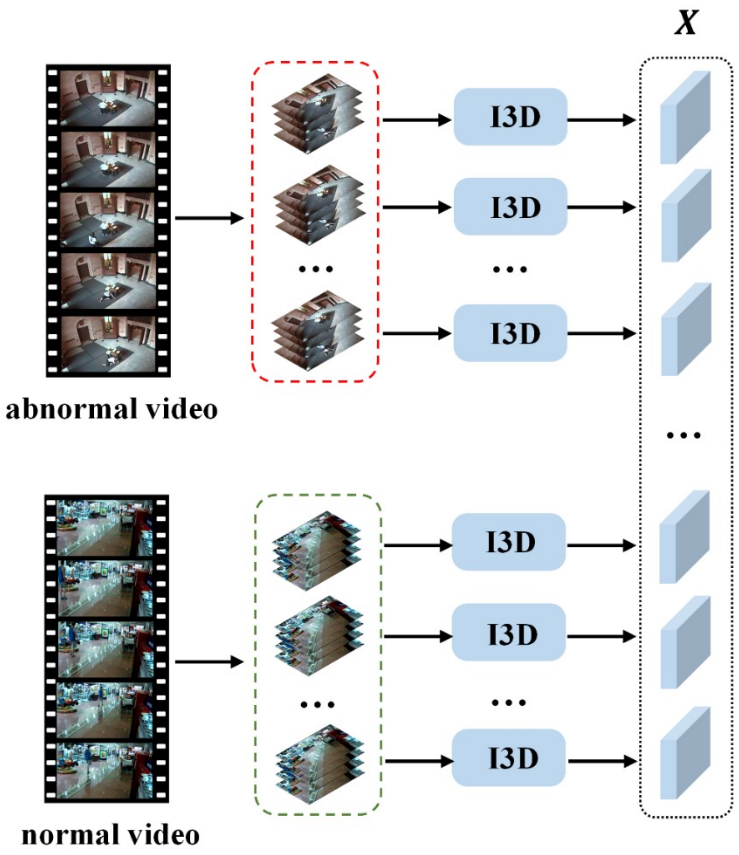
Methodology

Overall Structure of LA-Net with DDL method



Methodology

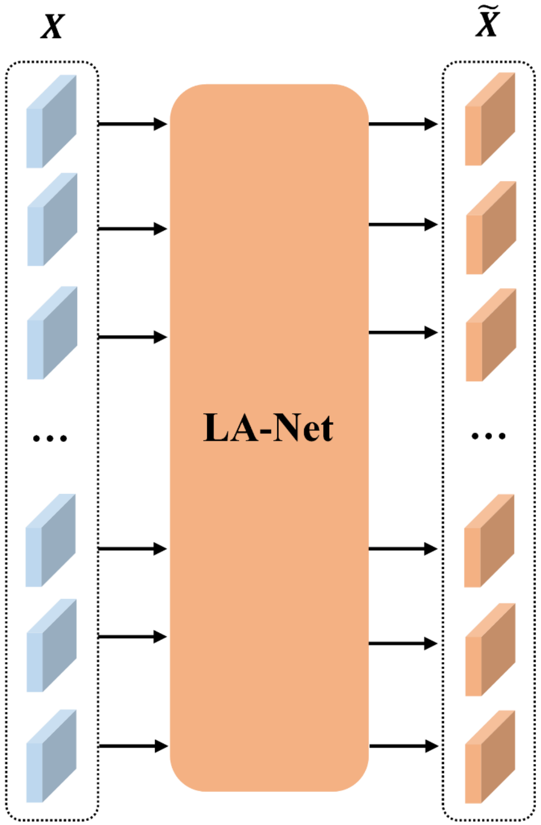
Feature Extraction

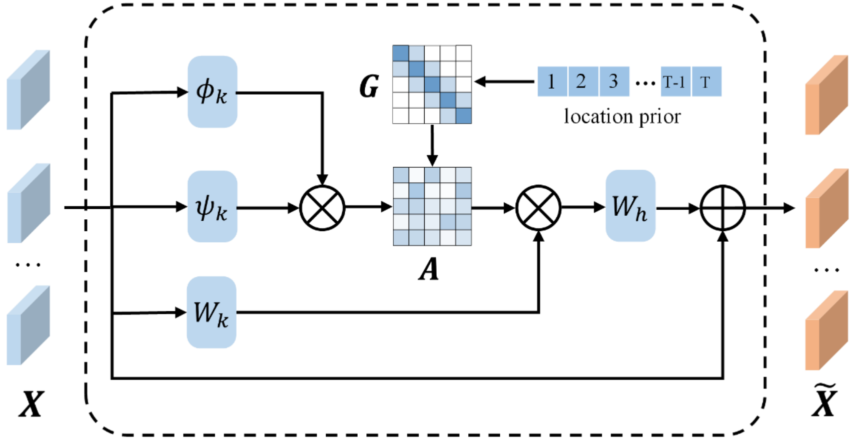


- Untrimmed Video $\mathcal{V}$
- Sliding Window $\chi = \{x_i\}_{i=1}^{T}$
- Snippet Feature $X = I3D(\chi) \in \mathbb{R}^{T \times D}$

Methodology

Locality-aware Attention Network





$$\mathcal{A}_{ij} = \frac{exp\{\mathcal{R}_k(x_i, x_j)\}}{\sum_{n=1}^{T} exp\{\mathcal{R}_k(x_i, x_n)\}}$$

$$\mathcal{R}_k = \phi(x_i)^T \psi(x_j)$$

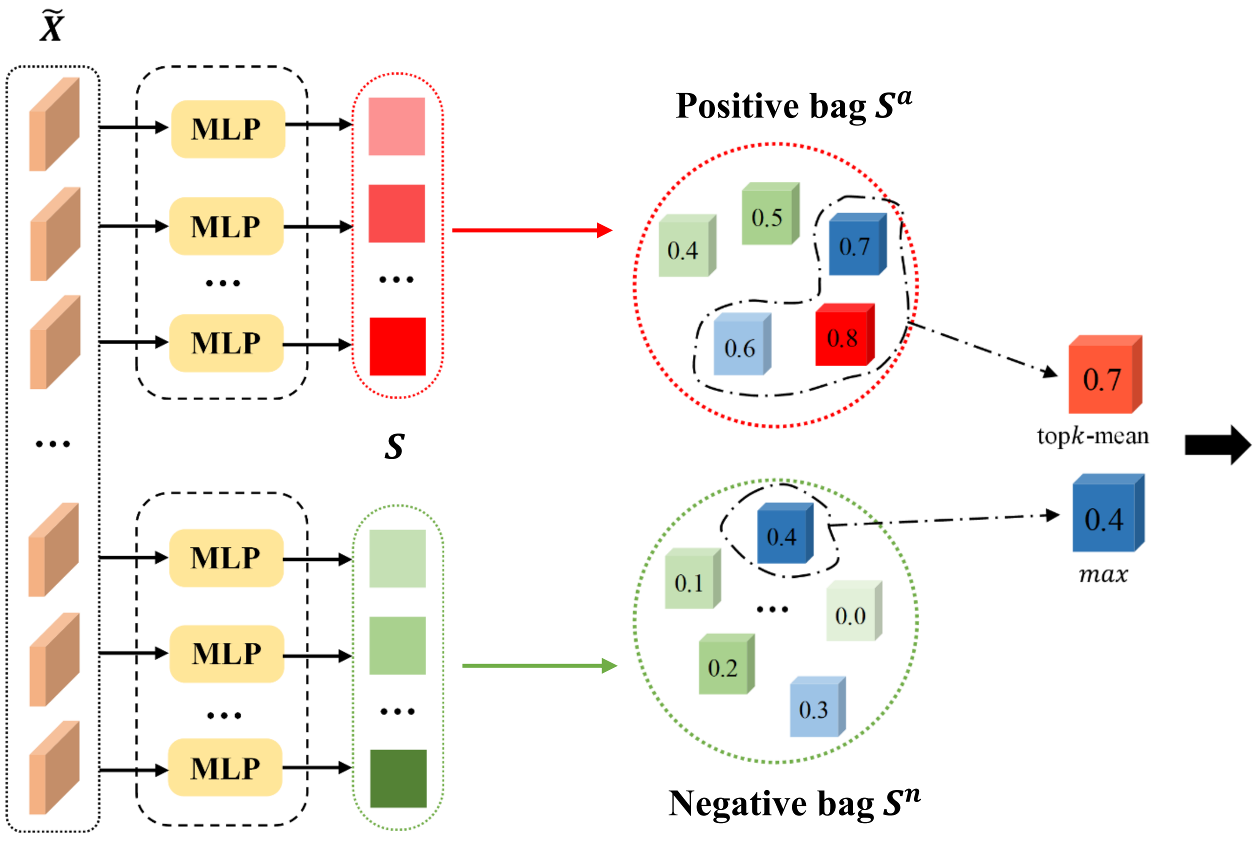
$$\mathcal{G}_{ij} = exp(-\frac{|i-j|^2}{2\sigma})$$

$$\widetilde{\mathcal{A}} = \mathcal{A} + \mathcal{G}$$

$$\widetilde{X} = Norm(stack(\widetilde{\mathcal{A}} X W_k) W_h + X)$$

Methodology

Multiple Instance Learning



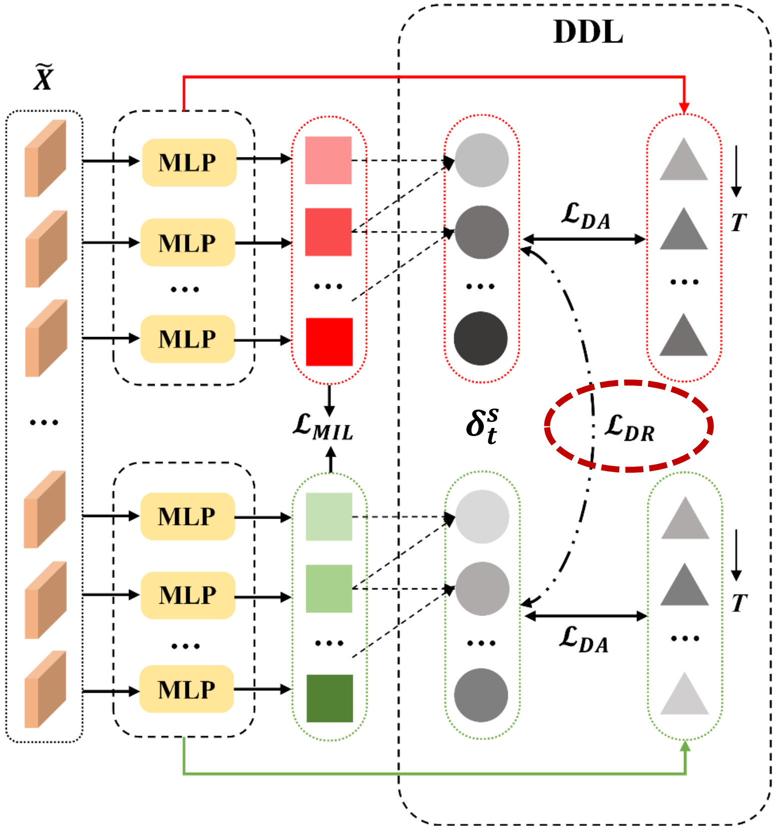
$$\mathcal{L}_{MIL} = \frac{1}{N}\sum_{i=1}^{N} -y_i \log(p_i)$$

$$\mathcal{S} = \sigma(W\mathcal{F}^{\Theta}(\widetilde{X}) + b)$$

$$p_i = \frac{1}{k}\sum_{i=1}^{k} Rank(S_i)$$

Methodology

Discriminative Dynamics Learning

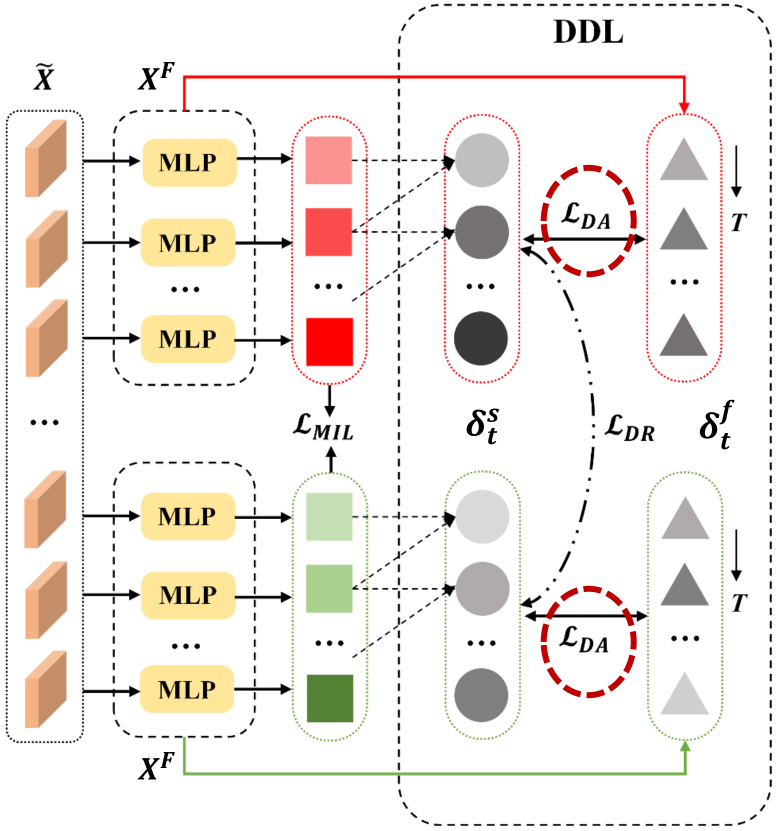


Score Dynamics Ranking --> **Outer Bag**

$$\left.\begin{aligned} S &= \{s_1, s_2, \dots, s_t\} \\ \delta_t^s &= |s_t - s_{t+1}| \\ \varepsilon_{\Delta S} &= \frac{1}{k}\sum_{t=1}^{k} |\delta_t^s|^2 \end{aligned}\right\} \quad \mathcal{L}_{DR} = max(0, \zeta - \mathcal{E}_{\Delta S}^{a} + \mathcal{E}_{\Delta S}^{n})$$

Methodology

Discriminative Dynamics Learning



Feature Dynamics **Alignment** --> Inner Bag

$$X^F = \{x_1^F, x_2^F, \dots, x_t^F\}$$

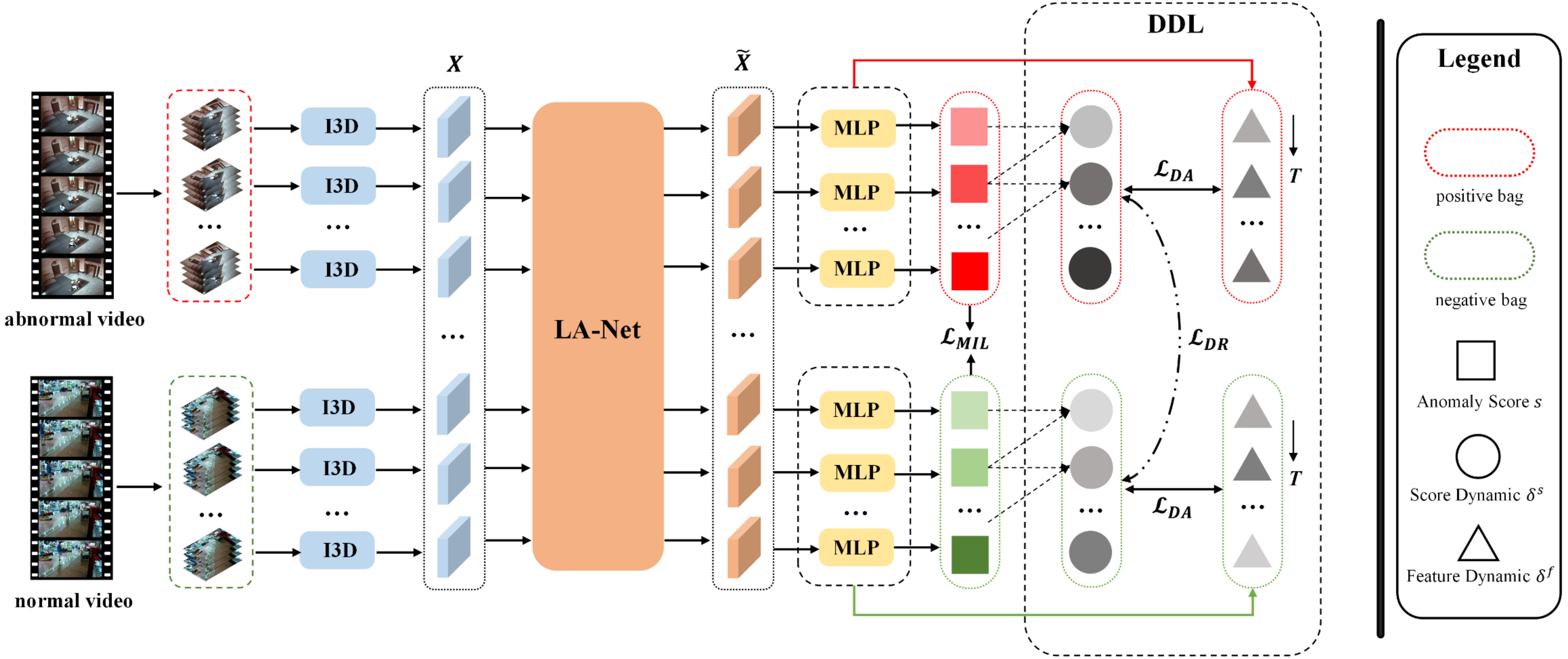
$$\delta_t^f = 1 - \frac{x_t^F x_{t+1}^F}{\|x_t^F\|\|x_{t+1}^F\|}$$

$$\delta_t^s = |s_t - s_{t+1}|$$

$$\mathcal{L}_{DA} = \frac{1}{N \times (T-1)} \sum_{i=1}^{N} \Big(\sum_{t=1}^{T-1} -\delta_t^s log(\delta_t^f + \epsilon) \Big)_i$$

Methodology

Overall Objective Function



$$\mathcal{L} = \mathcal{L}_{MIL} + \lambda_1 \mathcal{L}_{DR} + \lambda_2 \mathcal{L}_{DA}$$

Experimental Results

State-Of-The-Art Performance

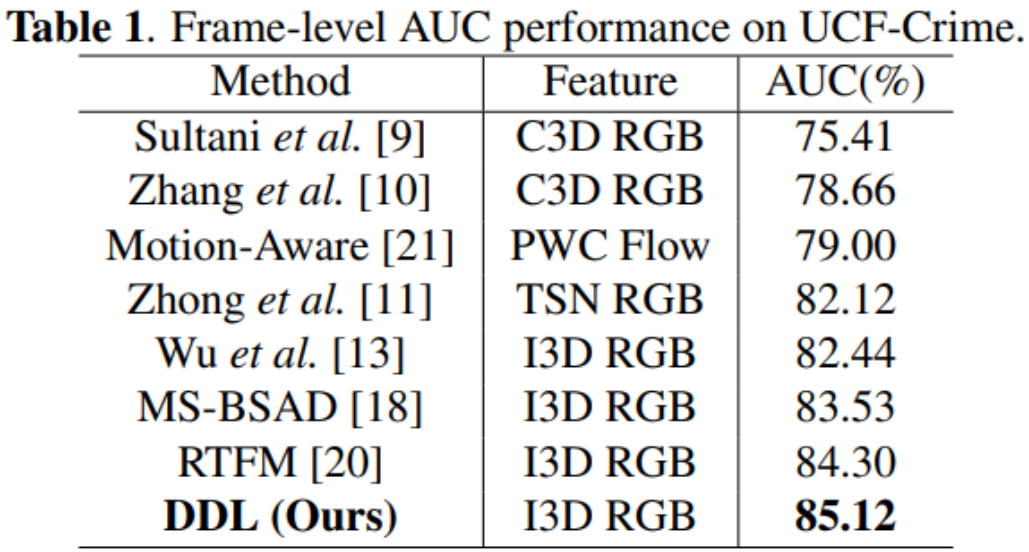


Table 1. Frame-level AUC performance on UCF-Crime.

Method	Feature	AUC(%)
Sultani *et al.* [9]	C3D RGB	75.41
Zhang *et al.* [10]	C3D RGB	78.66
Motion-Aware [21]	PWC Flow	79.00
Zhong *et al.* [11]	TSN RGB	82.12
Wu *et al.* [13]	I3D RGB	82.44
MS-BSAD [18]	I3D RGB	83.53
RTFM [20]	I3D RGB	84.30
DDL (Ours)	I3D RGB	**85.12**

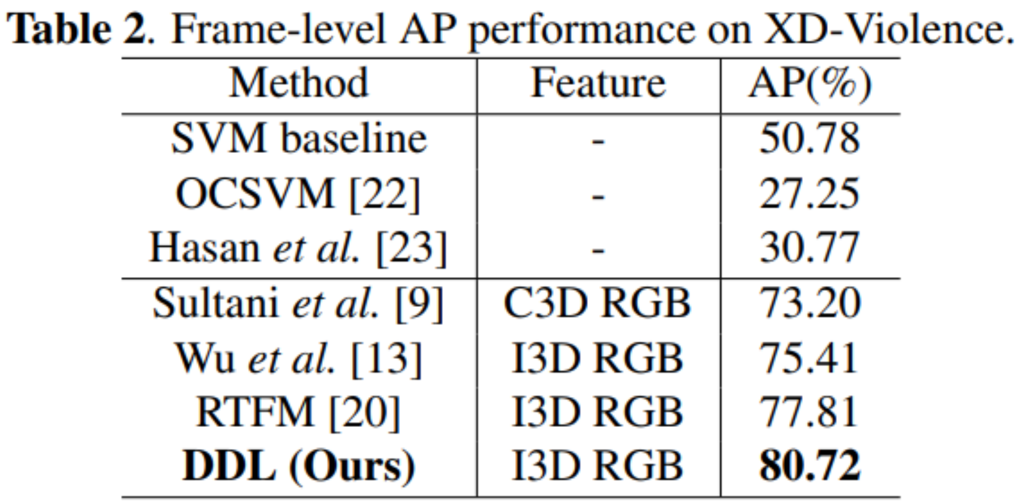


Table 2. Frame-level AP performance on XD-Violence.

Method	Feature	AP(%)
SVM baseline	-	50.78
OCSVM [22]	-	27.25
Hasan *et al.* [23]	-	30.77
Sultani *et al.* [9]	C3D RGB	73.20
Wu *et al.* [13]	I3D RGB	75.41
RTFM [20]	I3D RGB	77.81
DDL (Ours)	I3D RGB	**80.72**

Experimental Results

Ablation Study

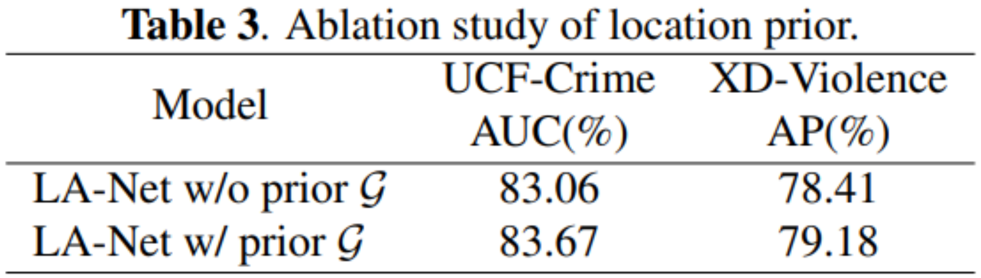


Table 3. Ablation study of location prior.

Model	UCF-Crime AUC(%)	XD-Violence AP(%)
LA-Net w/o prior $\mathcal{G}$	83.06	78.41
LA-Net w/ prior $\mathcal{G}$	83.67	79.18

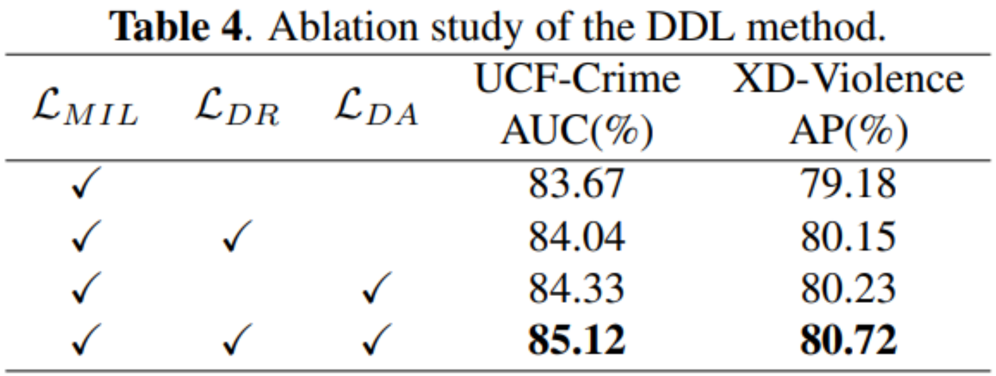
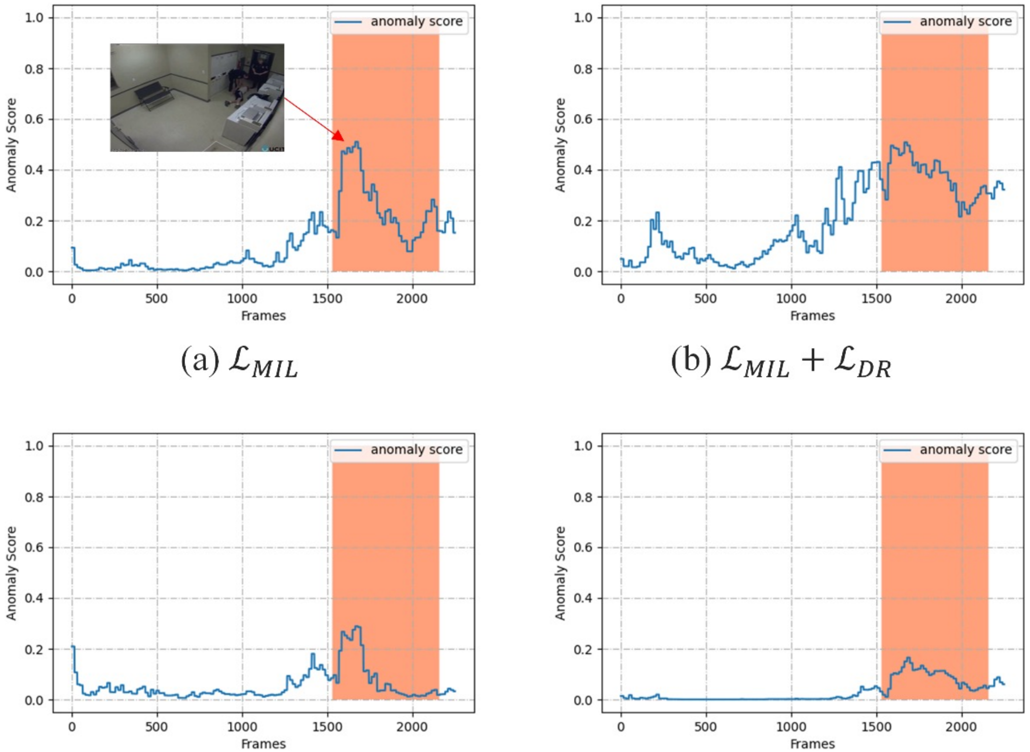


Table 4. Ablation study of the DDL method.

$\mathcal{L}_{MIL}$	$\mathcal{L}_{DR}$	$\mathcal{L}_{DA}$	UCF-Crime AUC(%)	XD-Violence AP(%)
✓			83.67	79.18
✓	✓		84.04	80.15
✓		✓	84.33	80.23
✓	✓	✓	**85.12**	**80.72**



(a) $\mathcal{L}_{MIL}$

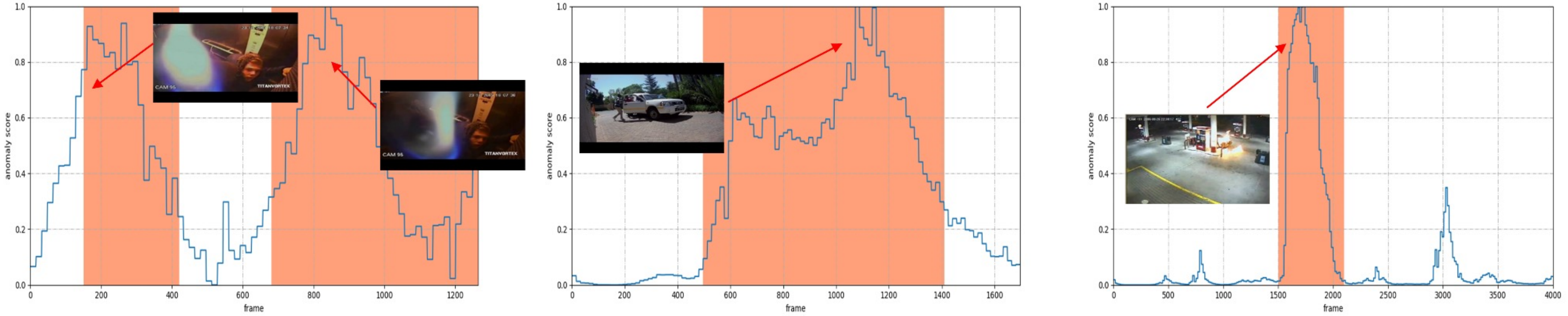
(b) $\mathcal{L}_{MIL} + \mathcal{L}_{DR}$

(c) $\mathcal{L}_{MIL}$+$\mathcal{L}_{DA}$

(d) $\mathcal{L}_{MIL} + \mathcal{L}_{DR} + \mathcal{L}_{DA}$

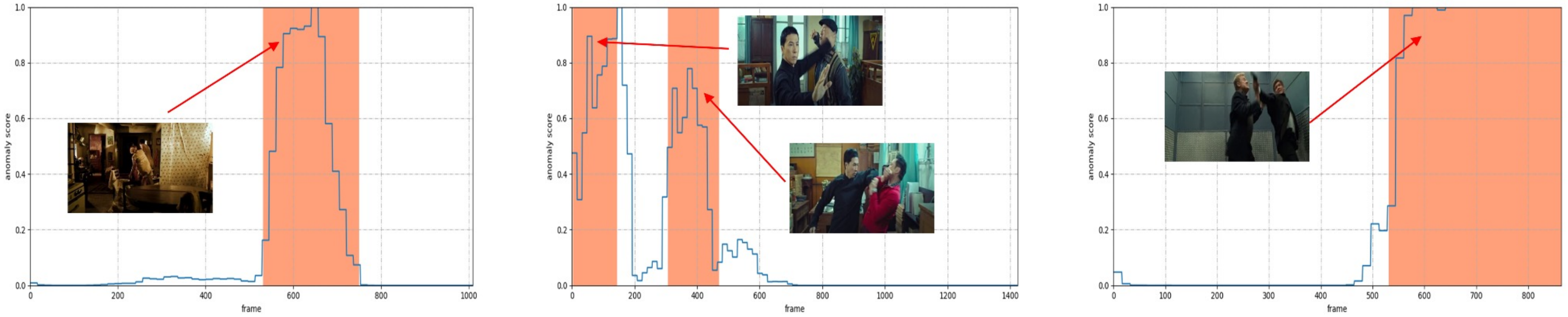
Qualitative Analysis

UCF-Crime



(a) Arson011 (b) Robbery050 (c) Explosion002

XD-Violence



(d) City.of.God.2002 (e) Ip.Man.3.2015 (f) Salt.2010

Thank You!