Anticipating Traffic Accidents with Adaptive Loss and Large-scale Incident DB

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* denotes equal contribution

Motivation

- Self-driving car **MUST** avoid a traffic accident
- Request for (i) **accidental videos in DB** (ii) **earlier anticipation**

Contributions

Technical Contribution

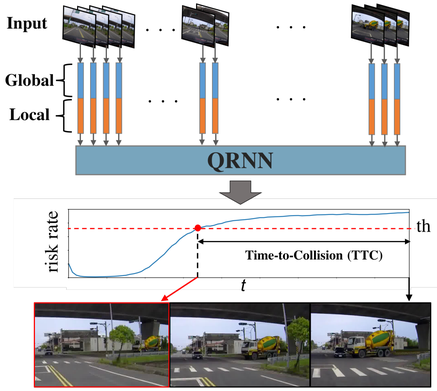
- **AdaLEA** (Adaptive Loss for Early Anticipation) which allows to gradually learn an earlier anticipation
- **QRNN** (Quasi-Recurrent Neural Net) in video recognition task

Database Contribution

- **NIDB** (Near-miss Incident DataBase) to understand and anticipate traffic accidents/incidents

System

1. **Global feature**
   - Use **NIDB pretrain model**
2. **Local feature**
   - Detect candidates of risk-factors
   - Use DSA [4]
3. **Time-sequential analysis**
   - Use **QRNN**
4. **Output the risk rate r_t**
5. **If $r_t > th$, Decide the presence of a future accident**



Loss function

Adaptive Loss for Early Anticipation (AdaLEA, ours)

for positive :

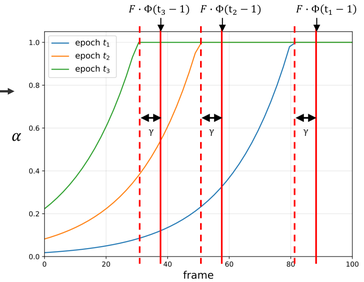
$$L^{p}_{LEA}(\{r_t\}) = \sum_{t=1}^{T} -\alpha \log(r_t)$$

$$\alpha = \exp\left(-\max(0, d - F \cdot \Phi(e-1) - \gamma)\right)$$

for negative :

$$L^{n}_{LEA}(\{r_t\}) = \sum_{t=1}^{T} -\log(1 - r_t)$$

$d = T - t$,
t : time, r_t : risk rate, F: frame rate, e: training epoch,
γ: hyper param, $\Phi(\cdot)$: function which returns ATTC



Always encourages an earlier anticipation than previous epoch

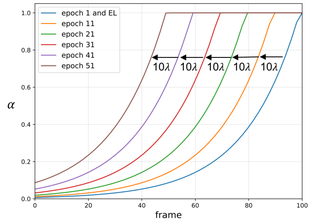
- Depending on **"how early the model can anticipate a traffic accident at each epoch"**, referring Average Time-To-Collision (ATTC)
- Ranges from easy (not early) anticipation to difficult (earlier) one according to training progress, like **Curriculum Leaning**

LEA (Loss for Early Anticipation, **ours**)

$$\alpha = \exp\left(-\max(0, d - \lambda \cdot (e-1))\right)$$

EL (Exponential Loss, conventional)

$$\alpha = \exp(-\max(0, d))$$

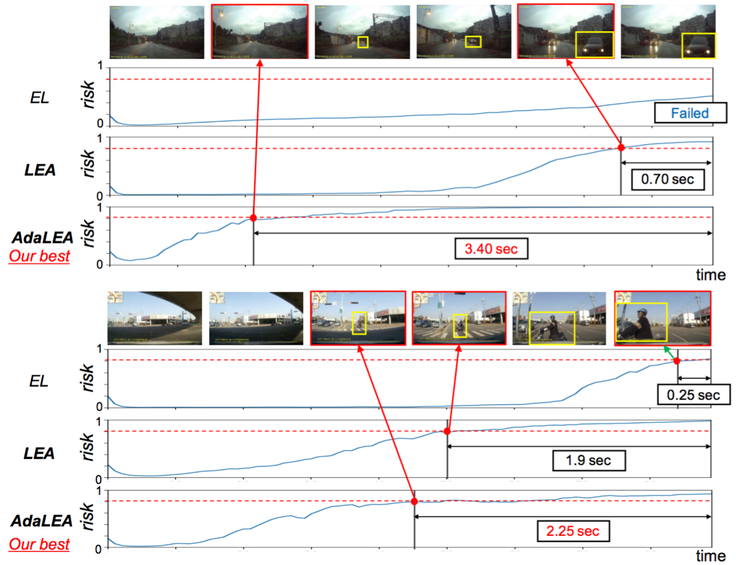


NIDB for anticipation

- **Large-scale** (4594 positives, 1650 negatives)
  - **7.7 × larger** positives than the conventional
- **Detail annotations**
  - **Risk-factors** {bicycle, pedestrian, vehicle}
  - **Near-miss duration** (start and end frame)

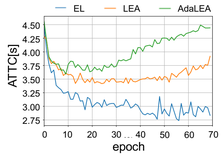
Results

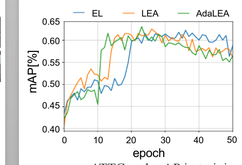
Qualitative Results



Quantitative Results

Encourages a model to anticipate earlier gradually





ATTC and mAP in training

Effectiveness of AdaLEA and QRNN in both metric

		Chan16 [4]	Chan16 +AdaLEA	QRNN +EL	Ours1 LEA	Ours2 AdaLEA
DSA		✓	✓	✓	✓	✓
LSTM		✓	✓			
QRNN				✓	✓	✓
EL		✓		✓		
LEA					✓	
Ada-LEA			✓			✓
mAP[%]	bicycle	57.3	57.7	60.0	**62.8**	56.8
	pedestrian	43.1	43.9	43.6	44.7	**47.9**
	vehicle	73.2	75.9	79.9	78.5	**81.4**
	Average	57.8	59.2	61.2	62.0	**62.1**
ATTC[s]	bicycle	2.94	3.38	3.51	3.22	**3.65**
	pedestrian	3.15	3.36	3.34	3.23	**3.56**
	vehicle	2.71	2.96	2.12	**3.99**	3.75
	Average	2.95	3.23	2.99	3.48	**3.65**

Result on NIDB

※ATTC : a metric to evaluate how early an accident is anticipated on average