A Conflict-aware Evidential Framework for Reliable Sleep Stage Classification

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Code (Github)

Paper (arXiv)

1.Introduction & Motivation

➢ **Problem:** Existing multi-view sleep staging methods assume **perfect alignment** between views, overlooking the **conflicts between EEG and EOG** signals.

➢ **Soulution: ConfSleepNet** introduces a conflict-aware evidential framework that:

- Learns physiologically meaningful classifications for multi-view inputs through a **hybrid category structure**.
- Dynamically resolves **inter-view conflicts**.
- Provides **reliable uncertainty-aware joint decisions**.

2.Design Principles

➢ **Complementarity:** EEG fine-grained (*W*, *N1*, *N2*, *N3*, *REM*) + EOG coarse-grained (*W*, *REM*, *NREM*) to respect **physiological roles**.

➢ **Consistent Views:** Combining consistent opinions reduces uncertainty → **more confident**.

➢ **Conflictive Views:** Conflicting high-uncertainty opinions increase overall uncertainty → **robustness**.

Conflict-Aware Aggregation (CMAM)

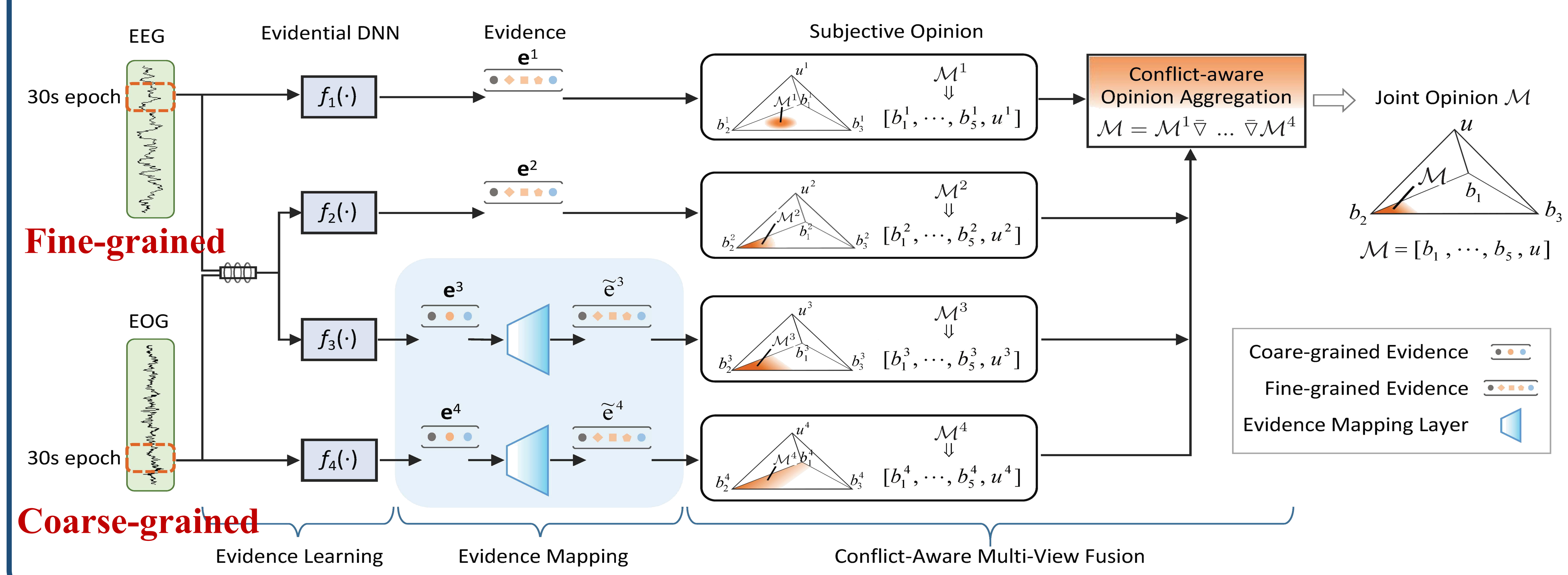
Conflice-degree metric: $C(\mathcal{M}^a,\mathcal{M}^b)=1-\frac{\sum_k b_k^a\cdot b_k^b}{\sum_i b_i^a\cdot\sum_j b_j^b}$

$$u^{a\bar{\nabla}b}=C\frac{2u^a u^b}{u^a+u^b}+(1-C)u^a u^b$$

$$b_k^{a\bar{\nabla}b}=\frac{u^a b_k^b+u^b b_k^a+(1-C)u^a u^b(b_k^a+b_k^b)}{u^a+u^b}$$

The aggregation rules provide **theoretical support** for the design principles.

3.Method: ConfSleepNet



4.Main Results

Dataset	DeepSleepNet	XSleepNet	TMCEK	ConfSleepNet
SleepEDF-20	82.0	86.4	85.0	**87.2**
SleepEDF-78	77.8	84.0	81.4	**85.3**
MASS-SS3	86.2	86.9	84.0	**88.9**
SHHS	81.0	87.6	84.3	**88.2**

The proposed ConfSleepNet achieves **optimal performance** on multiple sleep dataset

Dataset	EDL	RCML	TMCEK	ConfSleepNet
HandWritten	97.00	98.70	97.75	**98.45**
Scene15	60.60	71.28	71.06	**73.01**
CUB	89.51	93.28	90.50	**95.00**
PIE	87.99	93.89	95.15	**95.74**

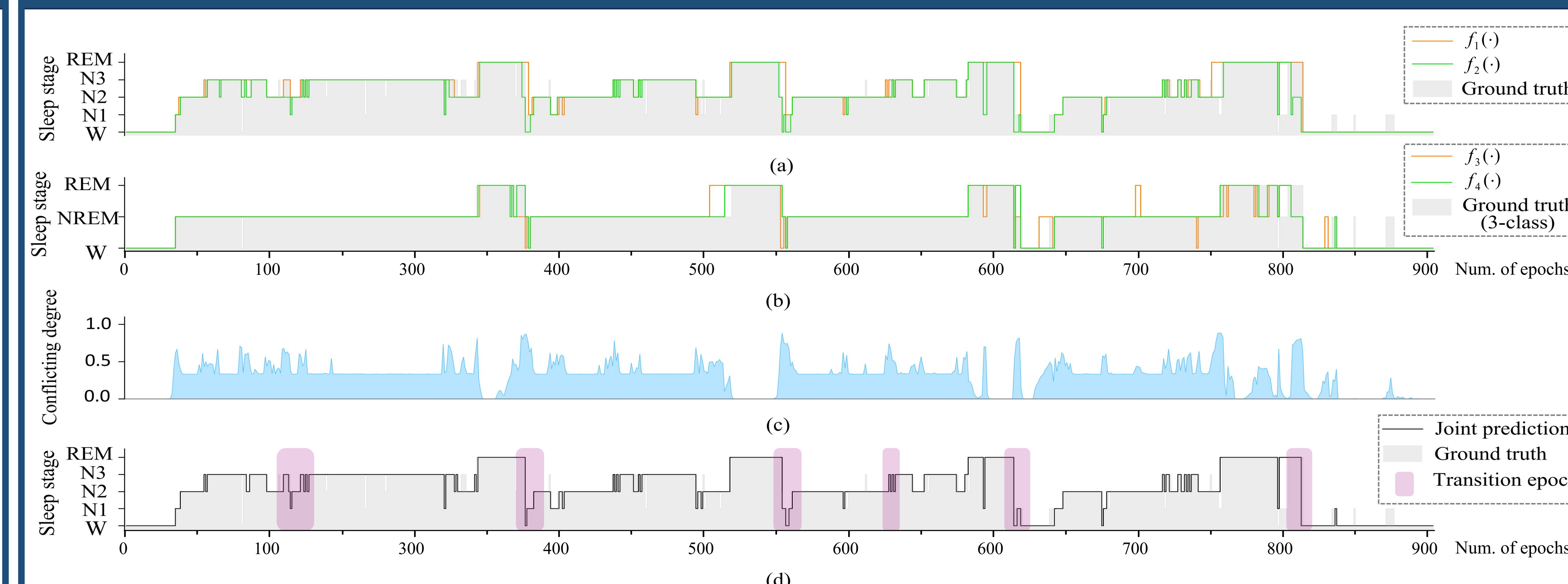
CMAM achieves **optimal performance** on multi-view benchmarks

5.Ablation Study

Variant	Acc	MF1
Avg. Fusion	87.4	82.5
RCML	88.4	83.6
No Hybrid	88.0	83.2
Full (Ours)	**88.9**	**84.2**

Hybrid granularity and **conflict-aware aggregation** have performance advantages.

6.Case Study



CMAM mitigates the influence of conflicts on the final decision.

7.Conclusion

➢ **Hybrid Category Structure** respects EEG/EOG complementarity.

➢ Novel **Conflict-Aware Multi-View Aggregation** with theoretical guarantees

➢ Outperforms **SOTA** on multiple public datasets, enhances clinical reliability during ambiguous epochs.