Driver State Modeling and Real-Time Estimation: A Case Study of Driver Fatigue

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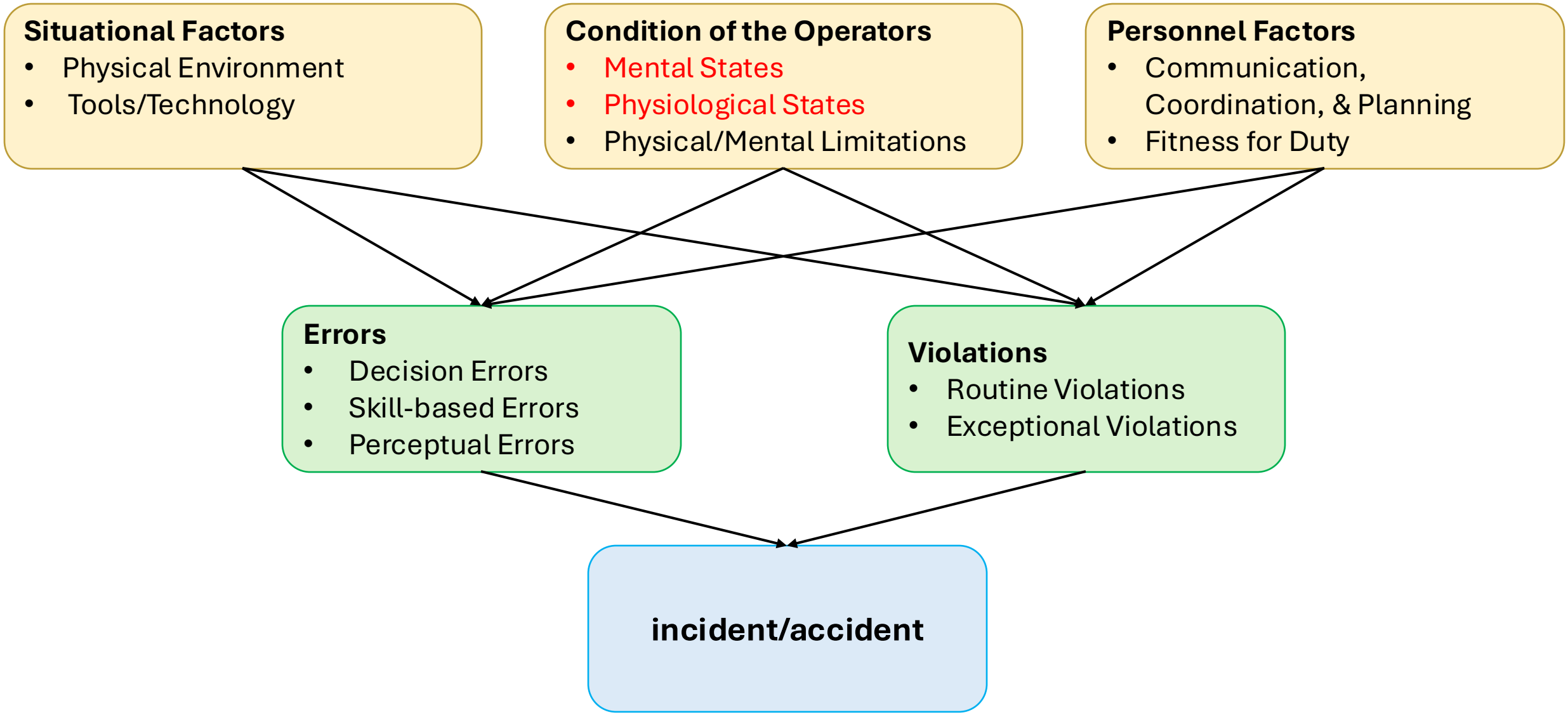
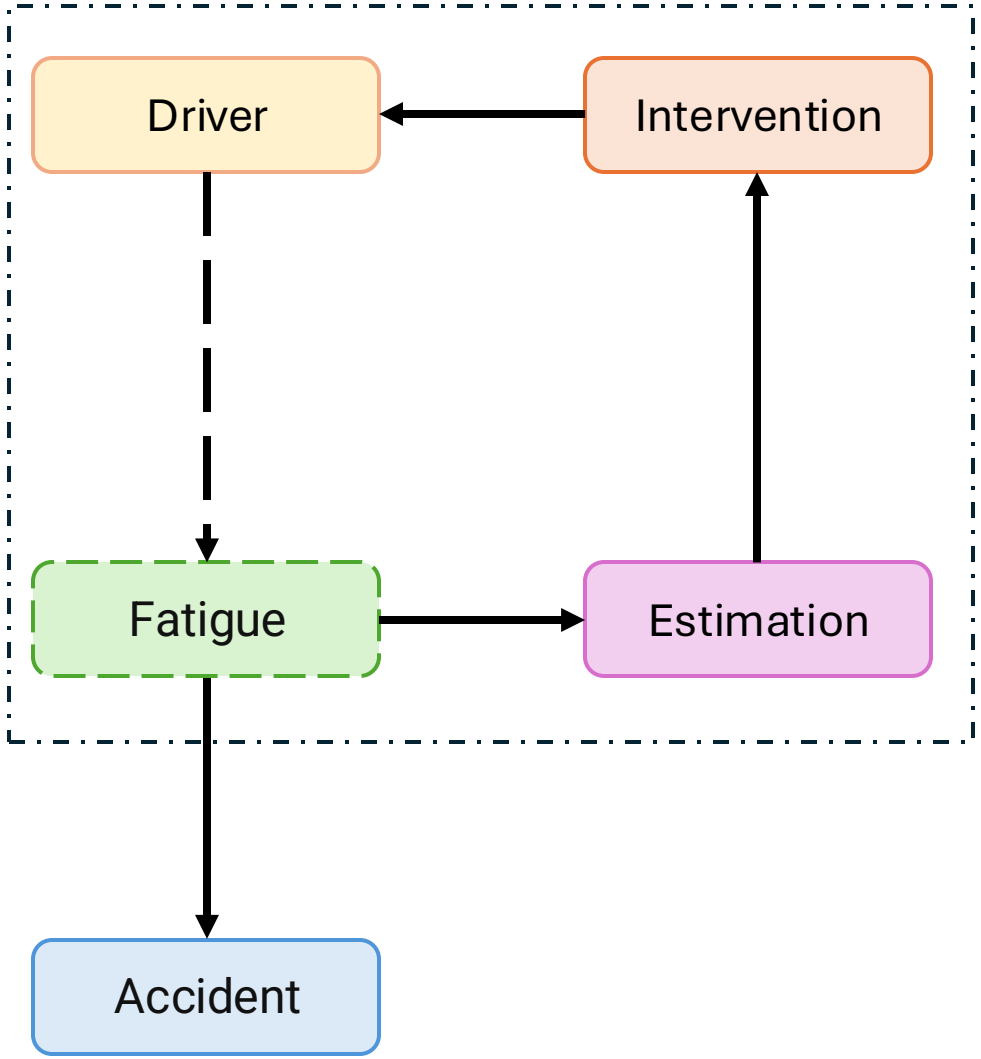
The Impact of Driver State on Traffic Safety

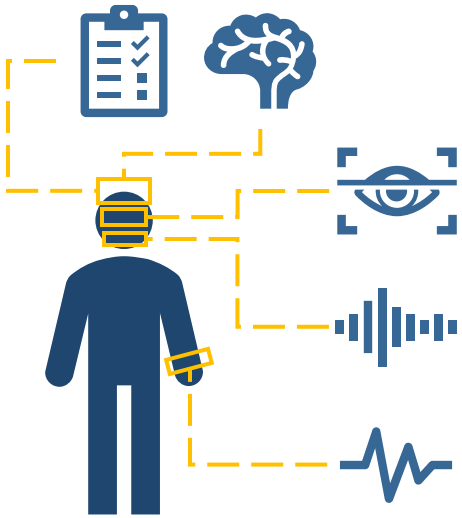


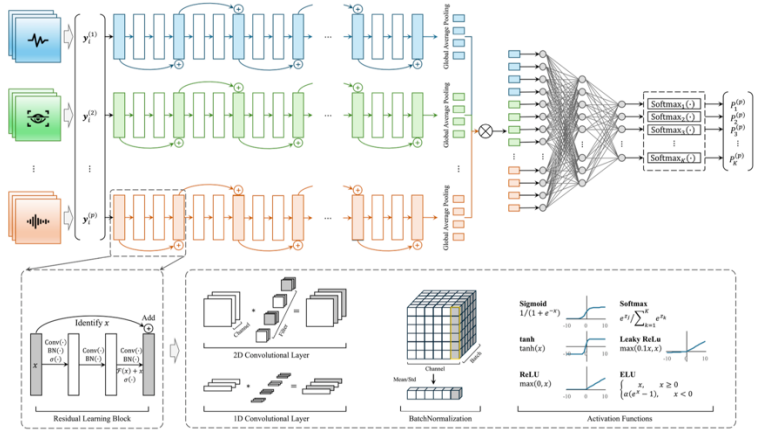
The Importance of Driver State Modeling and Estimation



Driver State Modeling

Driving Contexts → Driver States → Driver Responses





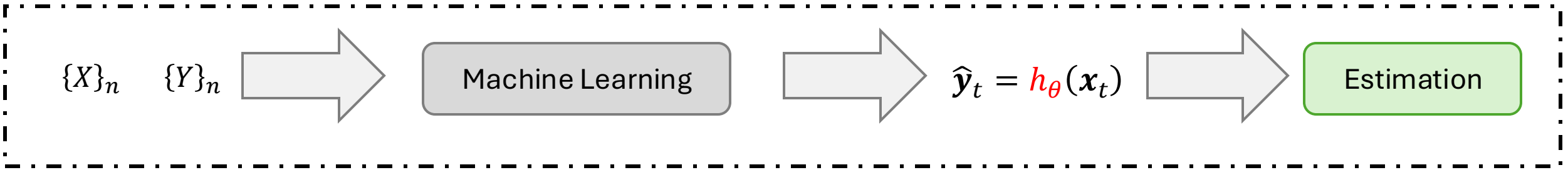
$$\boldsymbol{u}_t$$

$$\boldsymbol{y}_t = f(\boldsymbol{u}_t)$$

$$\boldsymbol{x}_t = g(\boldsymbol{y}_t)$$

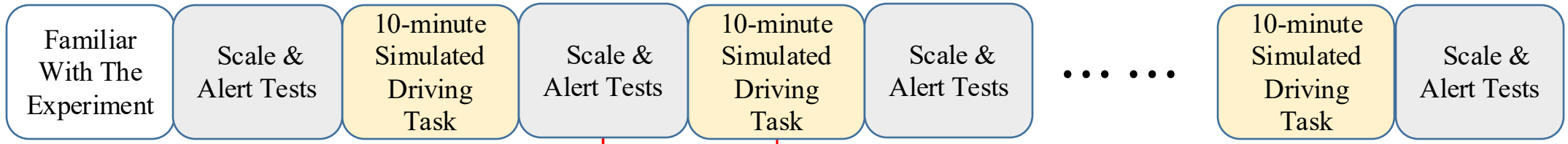
$$\hat{\boldsymbol{y}}_t = h_\theta(\boldsymbol{x}_t)$$

Driver Responses for State Estimation



- $\{X\}_n$
  - Biological Features
    - Heart Signal
    - Brain Signal
    - Skin Signal
    - Eye Signal
  - Vehicular Features
    - Steering Wheel
    - Lane Deviation
  - Physical Features
    - Eyes State
    - Mouth State
    - Face/Head State
- $\{Y\}_n$
  - Questionnaire or scale
  - Eyes State
  - Brain Signal
  - Reaction Time

Driver Fatigue Dataset



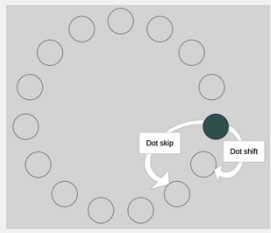
Scale (Self-reported Feelings)

Questionnaire					
Items	5-point scale				
I have distracting thoughts.	0	1	2	3	4
I feel totally exhausted.	0	1	2	3	4
I have lost my patience.	0	1	2	3	4
I make many mistakes at work.	0	1	2	3	4
I am easily fatigued.	0	1	2	3	4

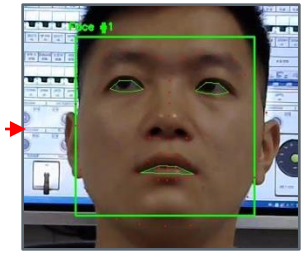
Karolinska Sleepiness Scale (KSS)	
Extremely alert	1
Very alert	2
Alert	3
Rather alert	4
Neither alert nor sleepy	5
Some signs of sleepiness	6
Sleepy, but no effort to keep awake	7
Sleepy, but some effort to keep awake	8
Very sleepy, great effort to keep awake, fighting sleep	9
Extremely sleepy, can't keep awake	10

Alert Test (Reaction Time)

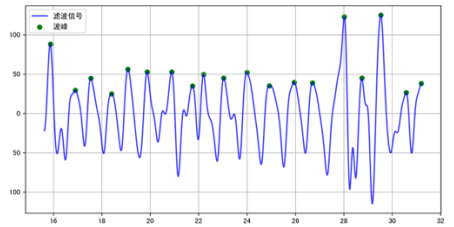
Mackworth Clock Task:
- Reaction time
- Status (1=correct, 2=incorrect, 3=missing, 4=timeout)



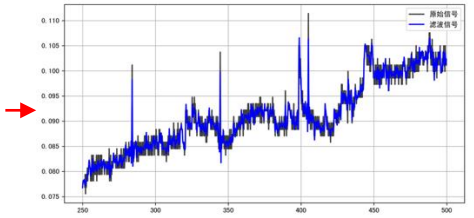
Logitech C270 camera



E4 Wristband

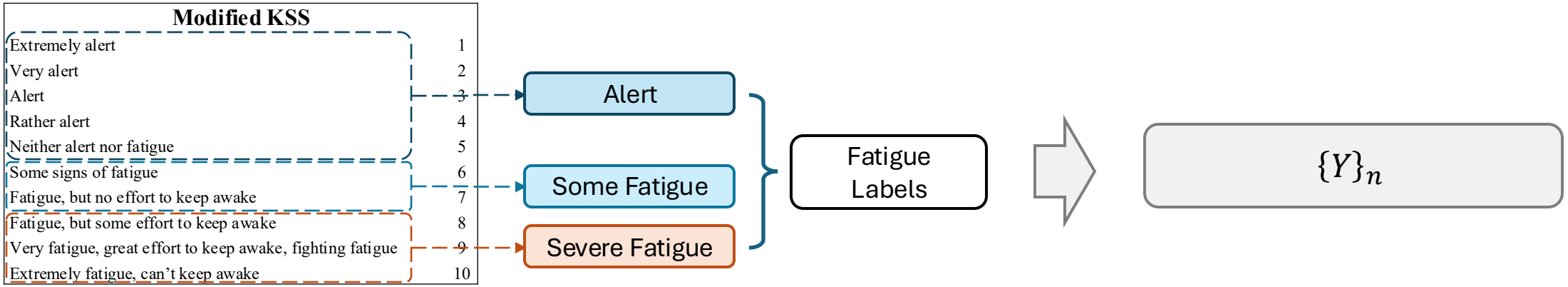


Blood Volume Pulse

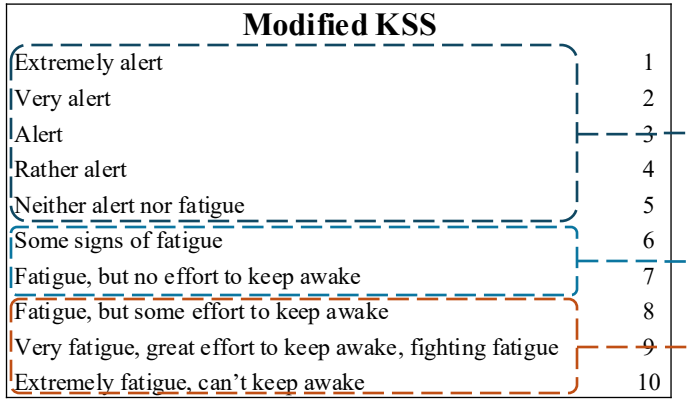


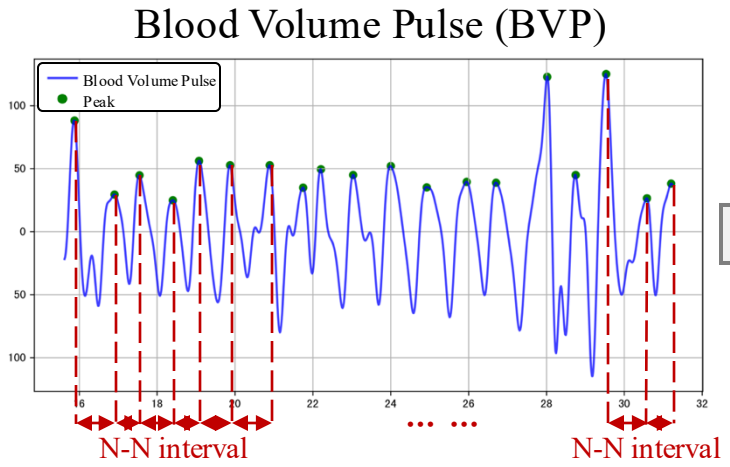
Electrodermal Activity

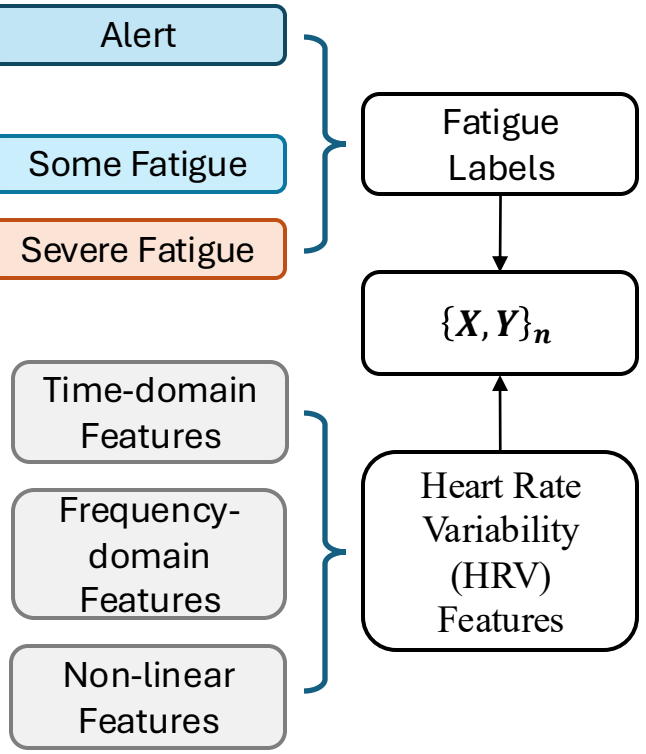
Fatigue Labels and Data

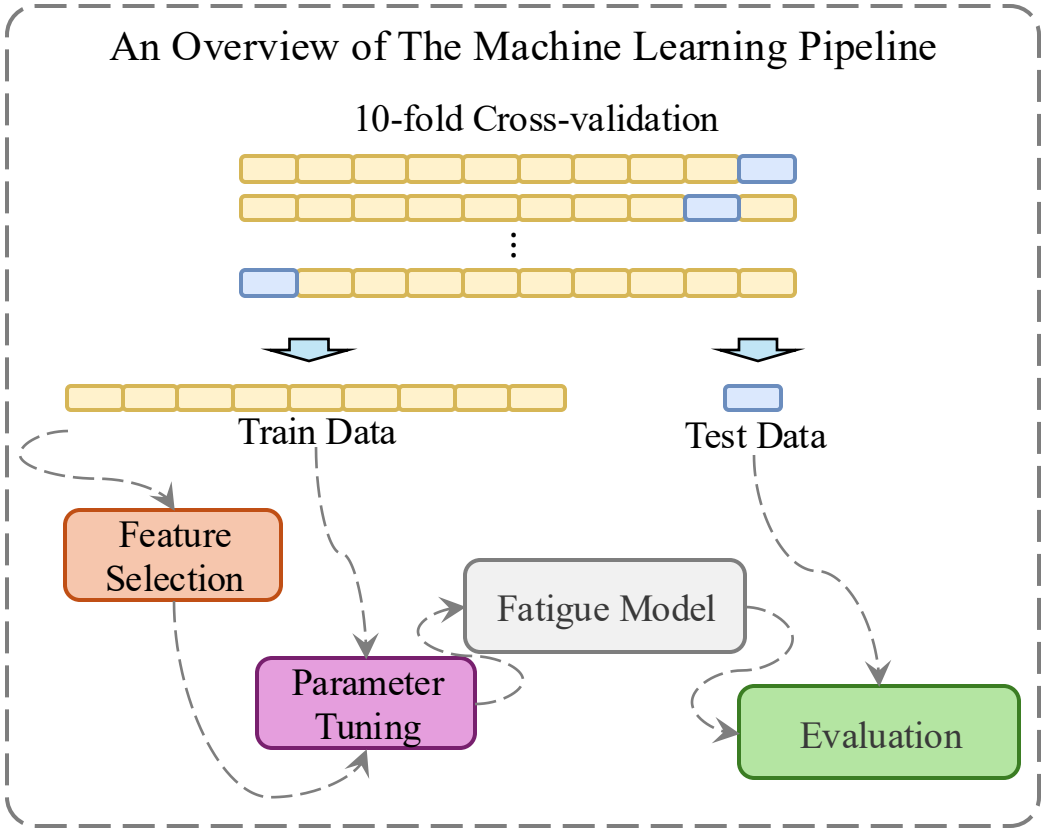


Fatigue Classification Using Heart Rate Signals

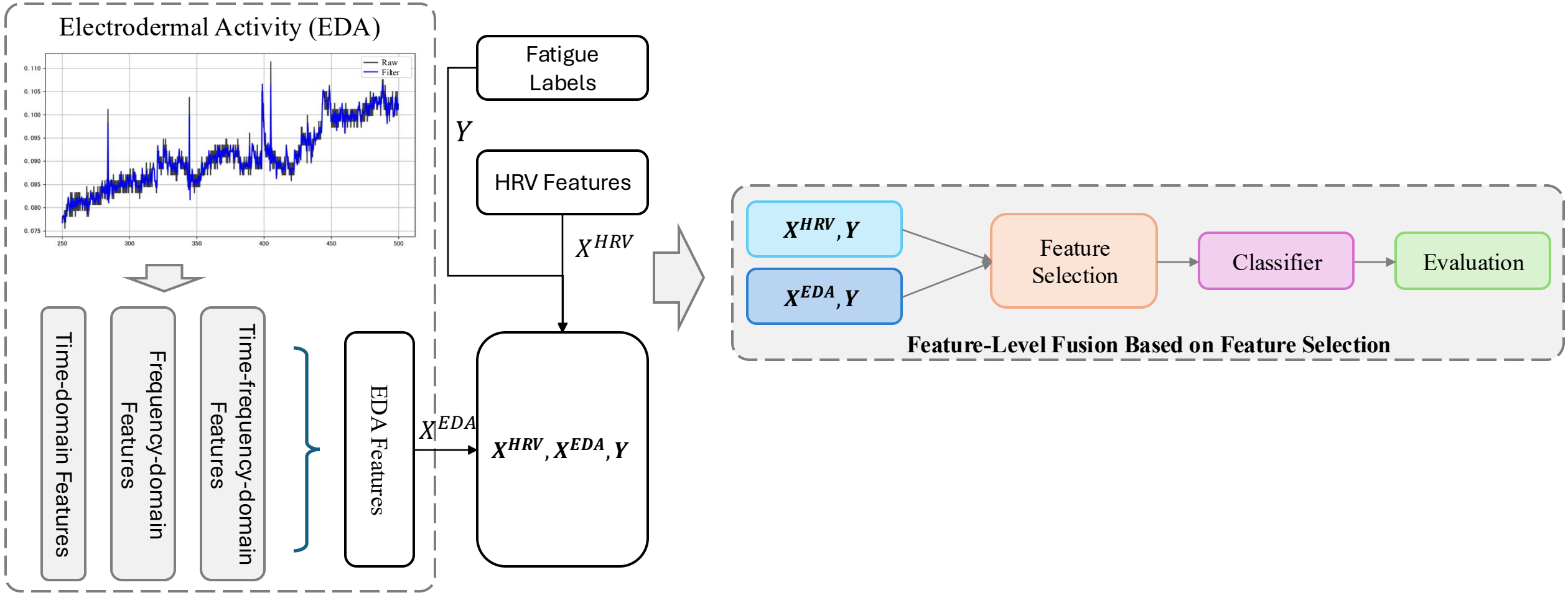




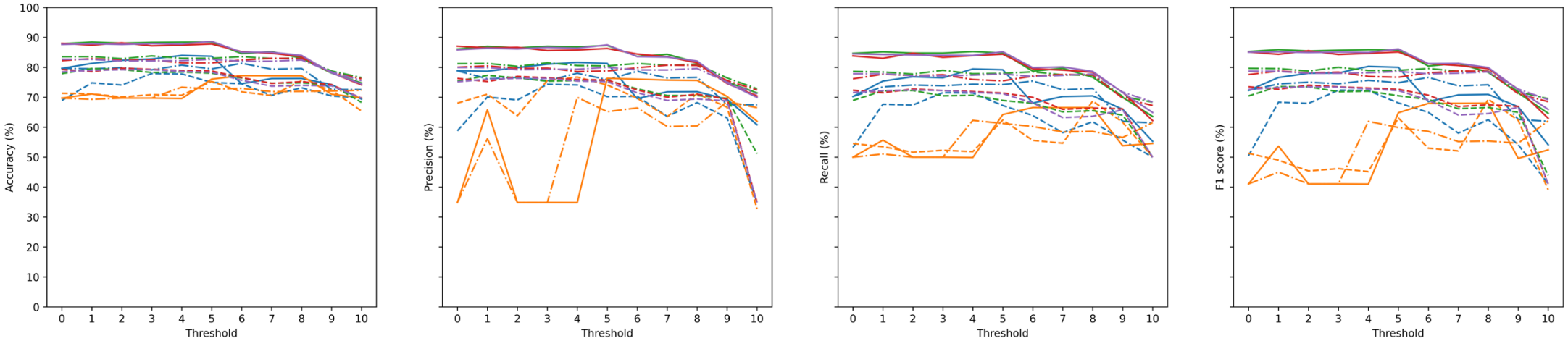




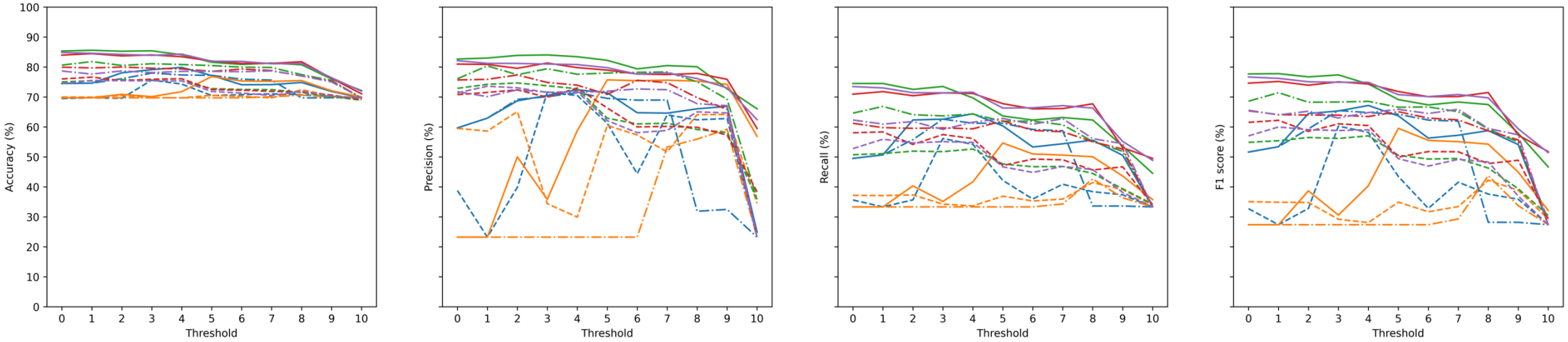
Fatigue Classification Using Heart Rate and Electrodermal Activity



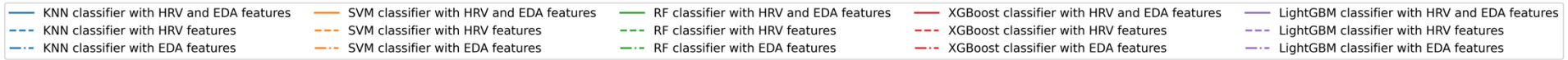
Results



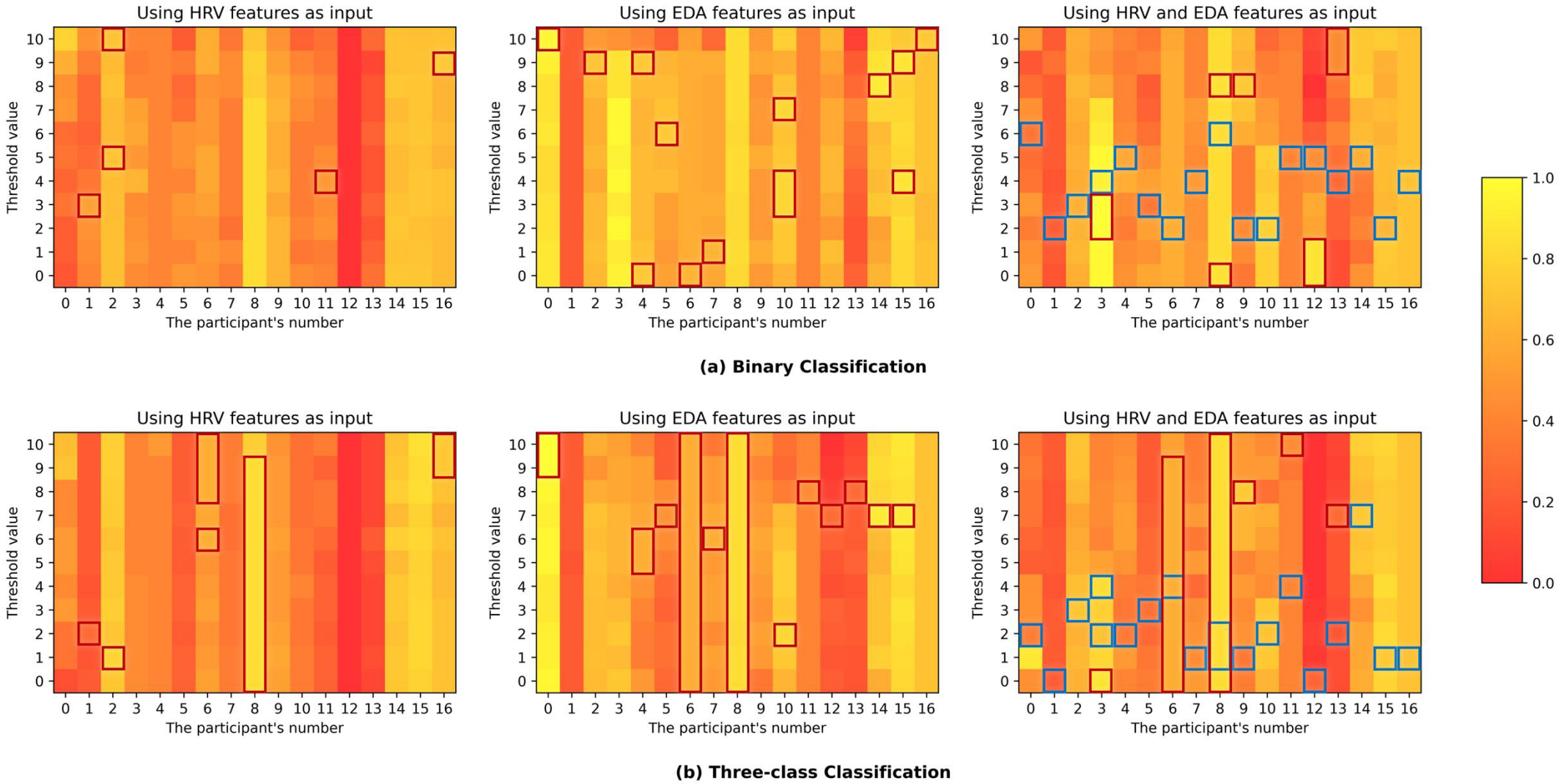
(a) Binary Fatigue Classification



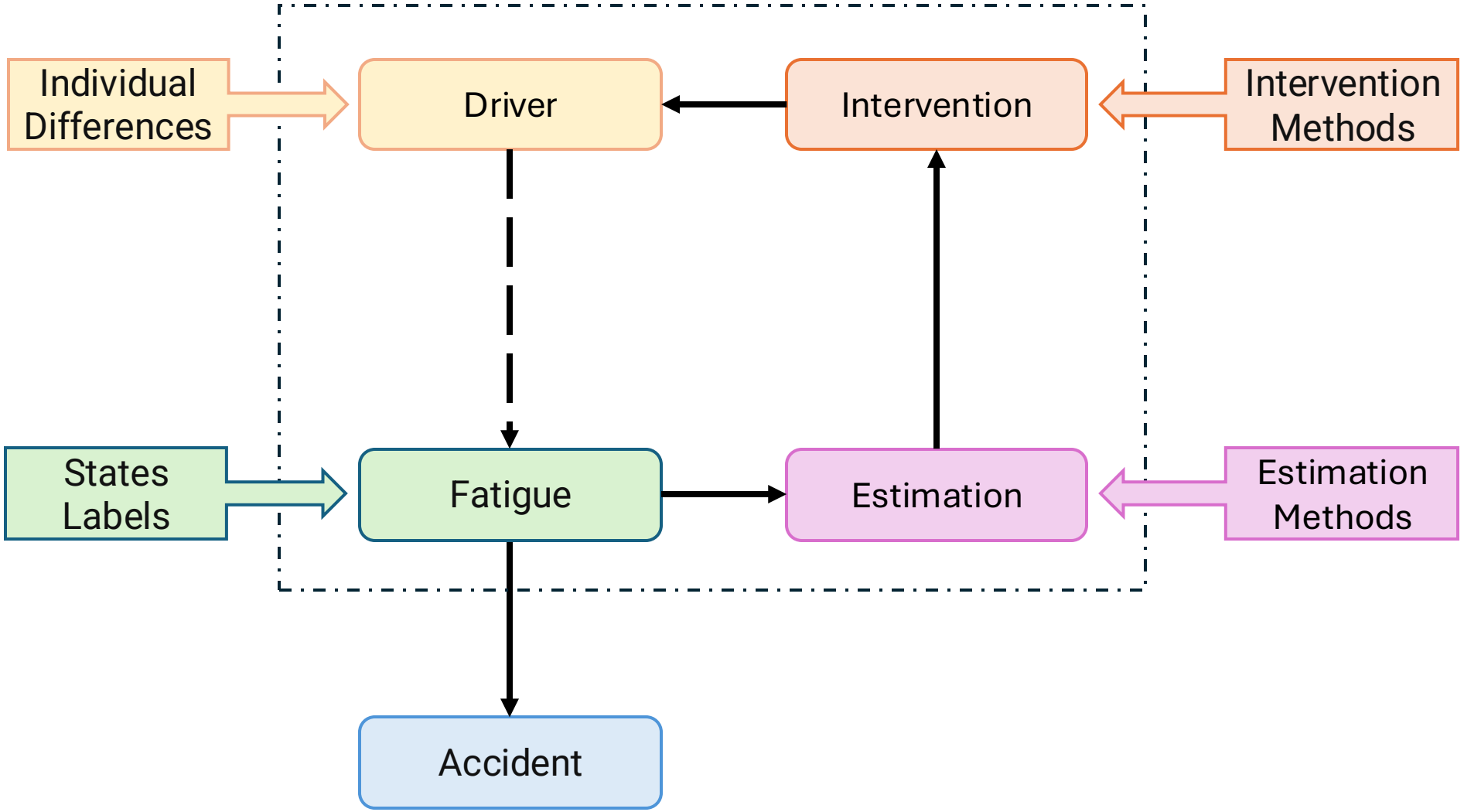
(b) Three-class Fatigue Classification



Individual Differences



Future Work


Individual Differences
Driver
Intervention
Intervention Methods
States Labels
Fatigue
Estimation
Estimation Methods
Accident