Every Rating Matters:

Joint Learning of Subjective Labels and Individual Annotators for Speech Emotion Classification

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Full Paper: https://ieeexplore.ieee.org/abstract/document/8682170

Slides: https://sigport.org/documents/every-rating-matters-joint-learning-subjective-labels-and-individual-annotators-speech

Overview

Purpose:

Speech emotion classification from acoustic features

- ✓ Task: 4 categories (Neutral, Happiness, Sadness, Anger)

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Speech emotion classification from acoustic features

- ✓ Task: 4 categories (Neutral, Happiness, Sadness, Anger)

Novelty:

A joint learning of **subjective labels** and **individual annotators** by utilizing soft-label and hard-label

- ✓ Use every rating (which are ignored in the previous work)
- ✓ Model individual annotators' emotion perception

Overview

Purpose:

Speech emotion classification from acoustic features

- ✓ Task: 4 categories (Neutral, Happiness, Sadness, Anger)

Novelty:

To joint learning of subjective labels and individual annotators, utilizing **soft-**label **and hard-**label (conventional methods)

- ✓ Use every rating (which are ignored in the previous works)
- ✓ Model individual annotators emotion perception

Results:

- Unweighted Accuracy Recall (UAR): 57.12 % → **61.48 %**

Background

What the...what am I doing?

Sadness, Anger

Sadness

Sadness, Anger

Background

Emotion perception is subjective because the natural bias of human, such as gender, age, and culture

What the...what am I doing?

Sadness, Anger

Sadness

Sadness, Anger

Suzuki, Atsunobu, et al. "Decline or improvement?: Age-related differences in facial expression recognition." Biological psychology 74.1 (2007): 75-84.
Hall, Judith A., and David Matsumoto. "Gender differences in judgments of multiple emotions from facial expressions." Emotion 4.2 (2004): 201.
Matsumoto, David. "American-Japanese cultural differences in the recognition of universal facial expressions." Journal of cross-cultural psychology 23.1 (1992): 72-84.

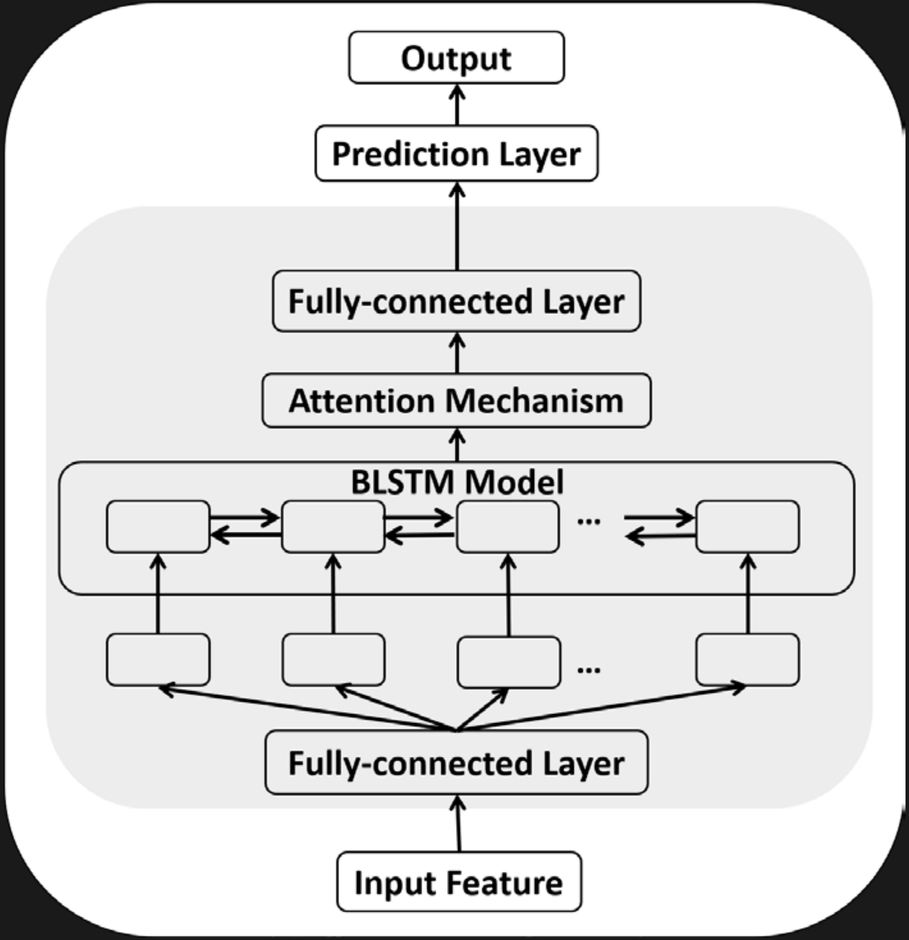
Conventional Method

Frame-level acoustic features + BLSTM-RNNs with Attention

Frame-level Features:

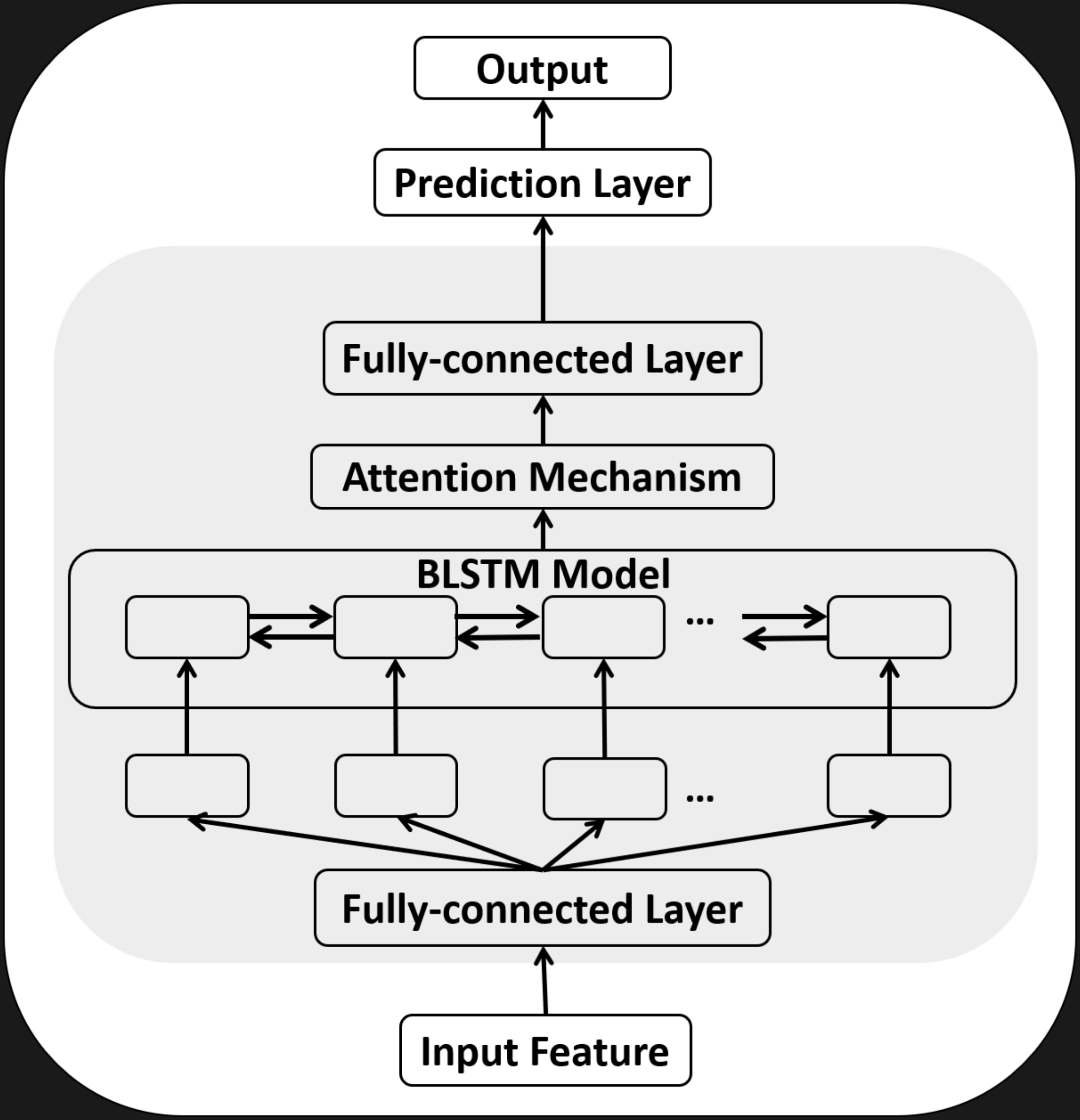
Pitch(F0), MFCCs, energy, loudness, voice probability, zero cross rate, … etc

(All features are extracted by openSMILE toolbox)



Mirsamadi, Seyedmahdad, Emad Barsoum, and Cha Zhang. "Automatic speech emotion recognition using recurrent neural networks with local attention." 2017 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). IEEE, 2017.

Conventional Method



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Data Label Preprocessing

Consensus (used in conventional method):

- ✓ **Majority vote of annotations**

=> Train emotion recognizer

Data Label Preprocessing

Working for corporate America? Wow.

Label

Data

Rating

Others Sadness Sadness

Ground Truth Usage

Data Label Preprocessing

Working for corporate America? Wow.

Label

Data

Rating   Others   Sadness   Sadness

Majority vote of ratings

Ground Truth Usage

Sadness

Hard-label Training

Model parameters are updated by cross-entropy loss:

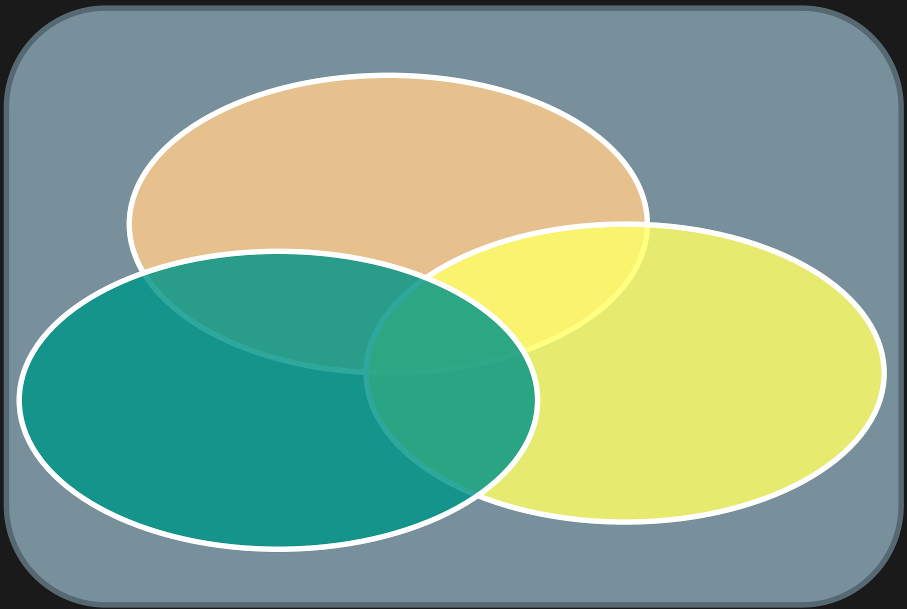
$$Loss = -\sum_{k=1}^{N}(p_k * log q_k),$$

$$q_k = [0, 0, 1, 0]$$

$$k = Total\ emotion\ classes$$

Conventional Method **Problem**

The **boundaries** between categories of emotion are **fuzzy** rather than discrete



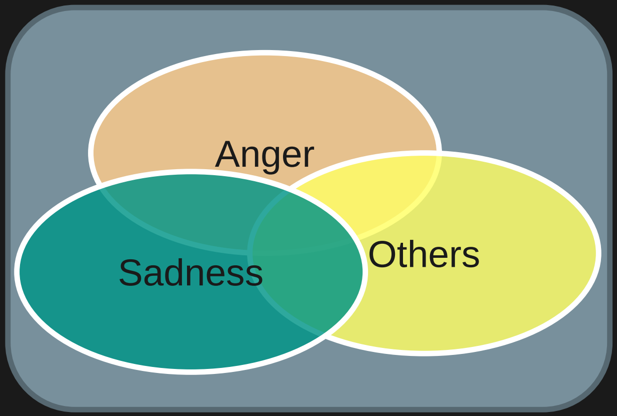
Discrete boundaries

Fuzzy boundaries

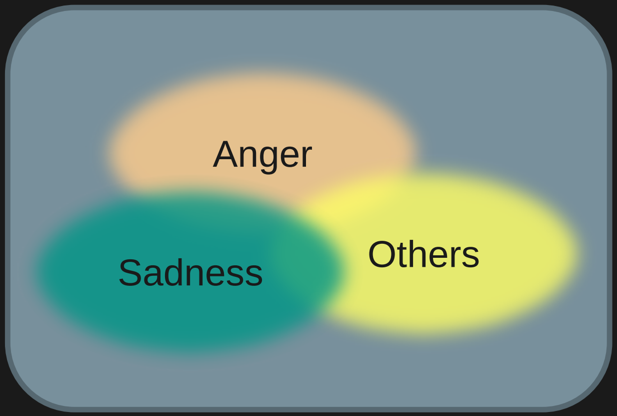
Cowen, Alan S., and Dacher Keltner. "Self-report captures 27 distinct categories of emotion bridged by continuous gradients." Proceedings of the National Academy of Sciences 114.38 (2017): E7900-E7909.

Conventional Method **Problem**

It just like the **same music** brings **different sense of emotion feelings** to different people



Discrete boundaries



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Conventional Method **Problem**

Emotion annotation can naturally have

disagreement and be ambiguous

Mower, Emily, et al. "Interpreting ambiguous emotional expressions." *2009 3rd International Conference on Affective Computing and Intelligent Interaction and Workshops*. IEEE, 2009.

Conventional Method **Problem**

Emotion annotation can naturally have

disagreement and be ambiguous

The hard label loses

➔ The variability of annotations

➔ The subjectivity in the emotion perception

Mower, Emily, et al. "Interpreting ambiguous emotional expressions." *2009 3rd International Conference on Affective Computing and Intelligent Interaction and Workshops*. IEEE, 2009.

Conventional Method **Another** Problem - **Why**

Working for corporate America? Wow.

Conventional Hard-label

Rating Others Sadness Anger

Ground Truth Usage

Conventional Method Problem - **Why**

Working for corporate America? Wow.

Conventional Hard-label

Rating Others Sadness Anger

No consensus

Ground Truth Usage

Conventional Method Problem - **Why**

Working for corporate America? Wow.

Conventional Hard-label

Rating Others Sadness Anger

Ground Truth Usage

No use ➔ **Training data limitation**

Soft-label Training

To address training data limitation

$$q(c_k) = \frac{\sum_n h_k^{(n)}}{\sum_{k'} \sum_n h_{k'}^{(n)}}$$

$$h_k^{(n)} = Binary\ label - existence(0/1),$$
$$n - th\ annotator, k - th\ emotion\ class$$

Steidl, Stefan, et al. "" Of all things the measure is man" automatic classification of emotions and inter-labeler consistency [speech-based emotion recognition]." *Proceedings.(ICASSP'05). IEEE International Conference on Acoustics, Speech, and Signal Processing, 2005.*. Vol. 1. IEEE, 2005.
Fayek, Haytham M., Margaret Lech, and Lawrence Cavedon. "Modeling subjectiveness in emotion recognition with deep neural networks: Ensembles vs soft labels." *2016 International Joint Conference on Neural Networks (IJCNN)*. IEEE, 2016.

Soft-label Training

$$q(c_k) = \frac{\alpha + \sum_n h_k^{(n)}}{\alpha K + \sum_{k'} \sum_n h_{k'}^{(n)}}$$

$$\boldsymbol{\alpha \;=\; Smoothing\ coefficient}$$

$$\boldsymbol{k \;= Total\ emotion\ classes}$$

$$h_k^{(n)} = Binary\ label - existence(0/1),$$
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Ando, Atsushi, et al. "Soft-Target Training with Ambiguous Emotional Utterances for DNN-Based Speech Emotion Classification." 2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). IEEE, 2018.

Soft-label Training

With soft label:

*** Solve training data limitation**

*** Characterize the fuzzy emotion perception**

$$q(c_k) = \frac{\alpha + \sum_n h_k^{(n)}}{\alpha K + \sum_{k'} \sum_n h_{k'}^{(n)}}$$

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Conventional Soft-label Method Problem - Why

What the...what am I doing?

Conventional Soft-label

Rating	**Sadness, Anger**	**Sadness**	**Anger, Sadness**

Ground Truth Usage	Sadness	Sadness	Anger

Only used one of them

Conventional Soft-label Method Problem - Why

What the...what am I doing?

Conventional Soft-label

Rating	Sadness, Anger	Sadness	Anger, Sadness

Ground Truth Usage	Sadness	Sadness	Anger

Emotional information lose

Conventional Soft-label Method Problem - **Solution**

Use one rating

Conventional Soft-label

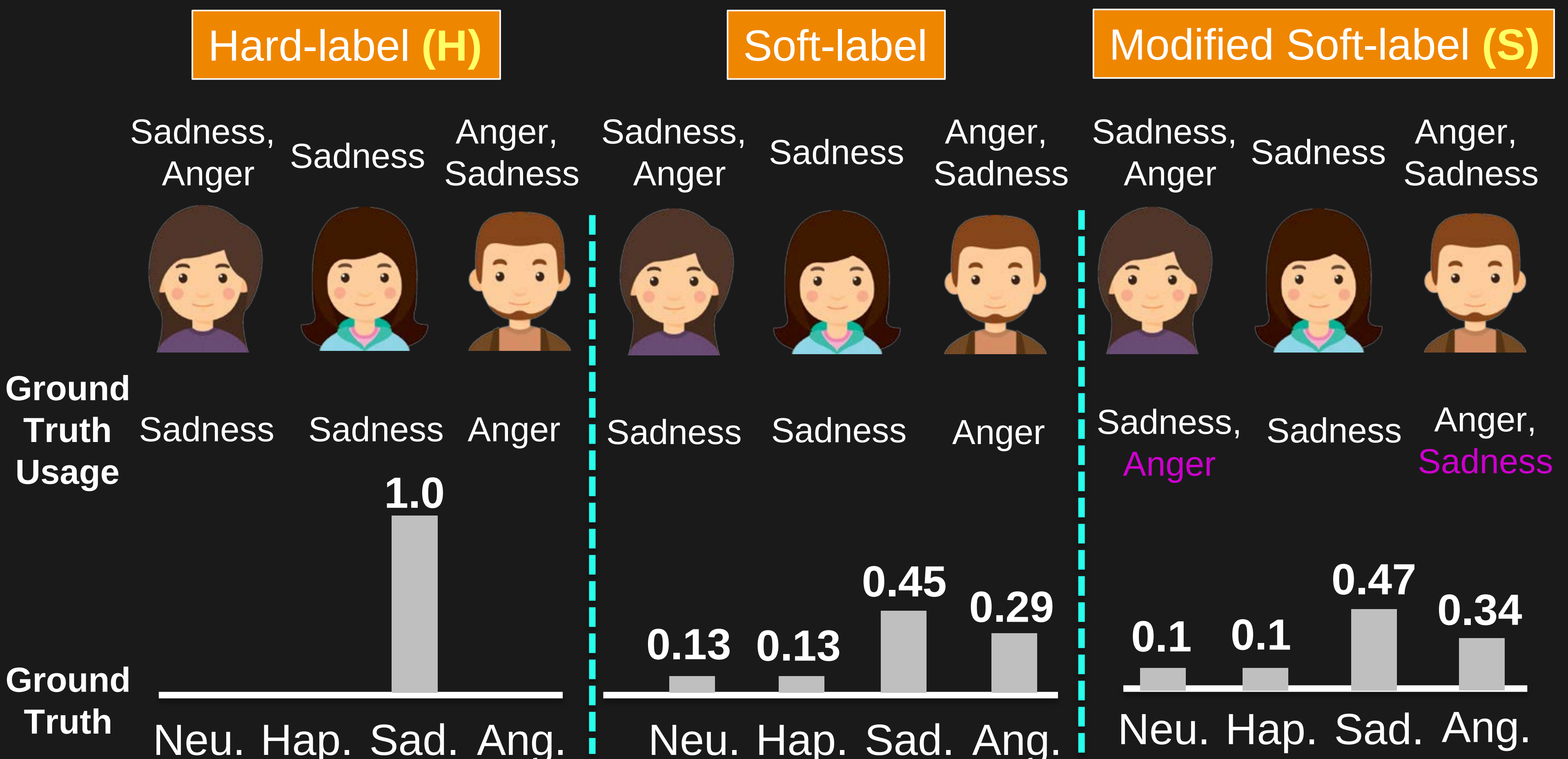
Rating	Sadness, Anger	Sadness	Anger, Sadness
			
Ground Truth Usage	Sadness	Sadness	Anger

Use **every** rating

Modified Soft-label

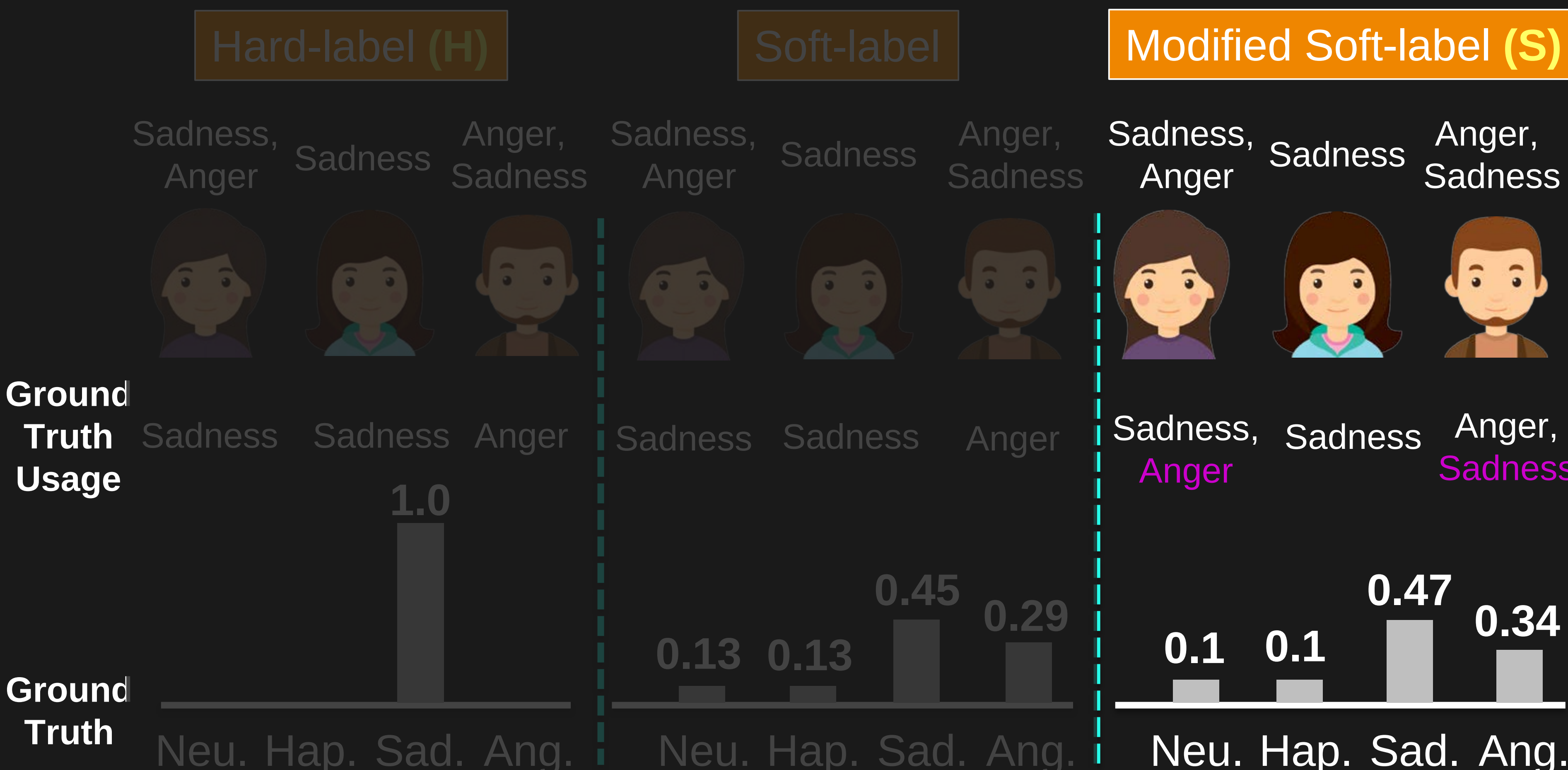
Sadness, Anger	Sadness	Anger, Sadness
		
Sadness, **Anger**	Sadness	Anger, **Sadness**

3 Different Targets



3 Different Targets

Modified soft label is useful to **represent subjective emotional information**



Model Emotional Sensitivity

- ✓ Use every rating
- ✓ **Build individual annotator's emotion perception sensitivity model**

Model Emotional Sensitivity

- ✓ **Emotional sensitivity** is different from person to person because the natural bias of human, like gender, age, and culture

Fang, Xia, Gerben A. van Kleef, and Disa A. Sauter. "Revisiting cultural differences in emotion perception between easterners and westerners: Chinese perceivers are accurate, but see additional non-intended emotions in negative facial expressions." *Journal of Experimental Social Psychology* 82 (2019): 152-159.

Fischer, Agneta H., Mariska E. Kret, and Joost Broekens. "Gender differences in emotion perception and self-reported emotional intelligence: A test of the emotion sensitivity hypothesis." *PloS one* 13.1 (2018): e0190712.

Montagne, Barbara, et al. "Sex differences in the perception of affective facial expressions: Do men really lack emotional sensitivity?." *Cognitive processing* 6.2 (2005): 136-141.

Martin, Rod A., et al. "Emotion perception threshold: Individual differences in emotional sensitivity." *Journal of Research in Personality* 30.2 (1996): 290-305.

McCluskey, Ken W., and Daniel C. Albas. "Perception of the emotional content of speech by Canadian and Mexican children, adolescents, and adults." *International Journal of Psychology*16.1-4 (1981): 119-132.

Model Emotional Sensitivity - Why

People use to **understand our own emotional experience** also **helps us understand the emotions of others**

↓

Model annotators' emotion sensitivity

Israelashvili, Jacob, et al. "Knowing me, knowing you: Emotion differentiation in oneself is associated with recognition of others' emotions." *Cognition and Emotion* (2019): 1-11.

Experiments

Purpose:

1. Use hard label and modified soft label for training
2. Model individual annotators' emotion perception
3. Joint all-annotators and individual models

Busso, Carlos, et al. "IEMOCAP: Interactive emotional dyadic motion capture database." Language resources and evaluation42.4 (2008): 335.

Experiments

Purpose:

1. Use hard label (**H**) and modified soft label (**S**) for training
2. Model individual annotators emotion perception
3. Joint all-annotators (**Crowd**) and individual model ($\mathbf{E_N}$)

Busso, Carlos, et al. "IEMOCAP: Interactive emotional dyadic motion capture database." Language resources and evaluation42.4 (2008): 335.

Experiments

Dataset: **IEMOCAP** Database

- Task: Dyadic emotional interaction (1 male, 1 female)
- Total # of session: **5**
- Total # of speakers: 10 (train: 8, test: 2 / per session)
- Average # of annotators / per each utterance: 3

  (**including self-report and observe-report**)
- # of chose individual annotators **(only observed)**: 5

Busso, Carlos, et al. "IEMOCAP: Interactive emotional dyadic motion capture database." Language resources and evaluation42.4 (2008): 335.

Data Usage

Purpose:

1. Use H label and S label for train
2. Model 5 observed annotators emotion perception ($\boldsymbol{E_1 \sim E_6}$)
3. Joint **Crowd and $\mathbf{E_N}$ (**will be discussed in the setups**)**

The # of S and H label utterance for each model			
Model	Total	Soft label	Hard label
$Crowd_H$	5531	0	5531
$Crowd_S$	7774	3185	4589
$E1$	5954	44	5910
$E2$	7845	38	7807
$E4$	6429	212	6217
$E5$	422	3	419
$E6$	773	20	753

Data Usage

Purpose:

1. Use H label and S label for train

All-annotators model:

- H: use hard-label
- S: use soft-label

(**Baselines**)

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- H: use hard-label
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(**Baselines**)

Individual model:
- **Use soft-label**

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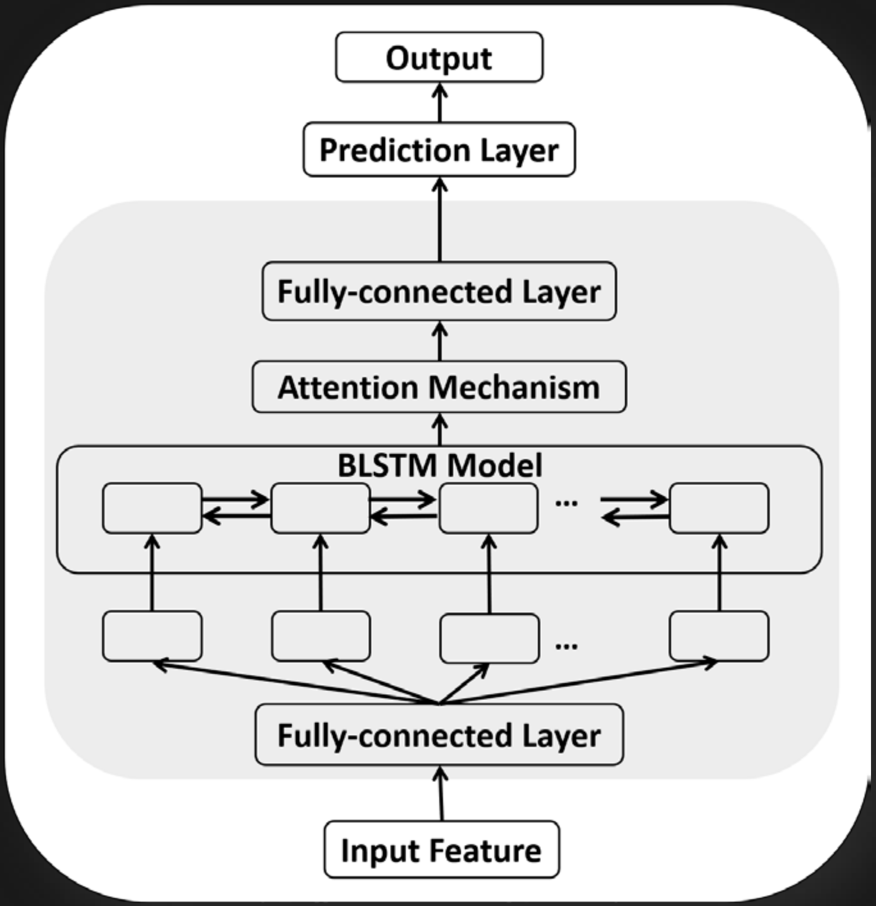
Setups

Classifier: BLSTM with attention [Ando + , 2018]

- Main Structure
    - [Dense,256]-[BLSTM with attention,128]- [Dense,256]



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Classifier: BLSTM with attention [Ando + , 2018]

- Main Structure
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- Input: acoustic low level descriptors (LLDs), 45 dims.
  - **12 MFCCs, Δ12 MFCCs, ΔΔ12 MFCCs,**
  - **Loudness, Δ Loudness, ΔΔ Loudness**
  - **Pitch (F0), Δ Pitch (F0),**
  - **Probability of voicing, Δ Probability of voicing,**
  - **Zero-crossing rate, Δ Zero-crossing rate**

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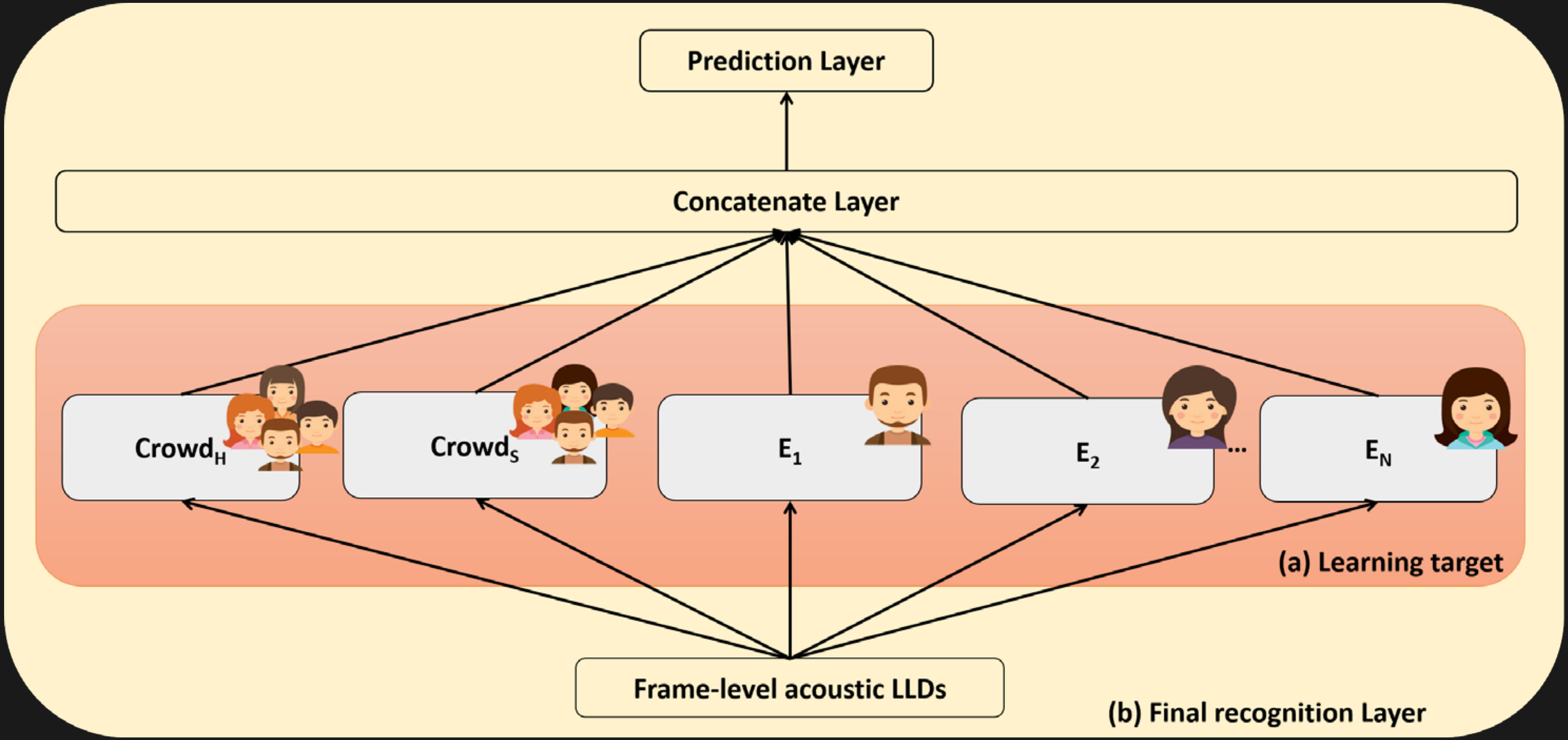
  - **Pitch (F0), Δ Pitch (F0), Probability of voicing, Δ Probability of voicing,**
  - **Zero-crossing rate, Δ Zero-crossing rate**
- Target: **Hard-label (when testing)**

Evaluation measure: Unweighted Accuracy Recall (UAR)

- Average results of 5 sessions (**Leave-one-session-out**)

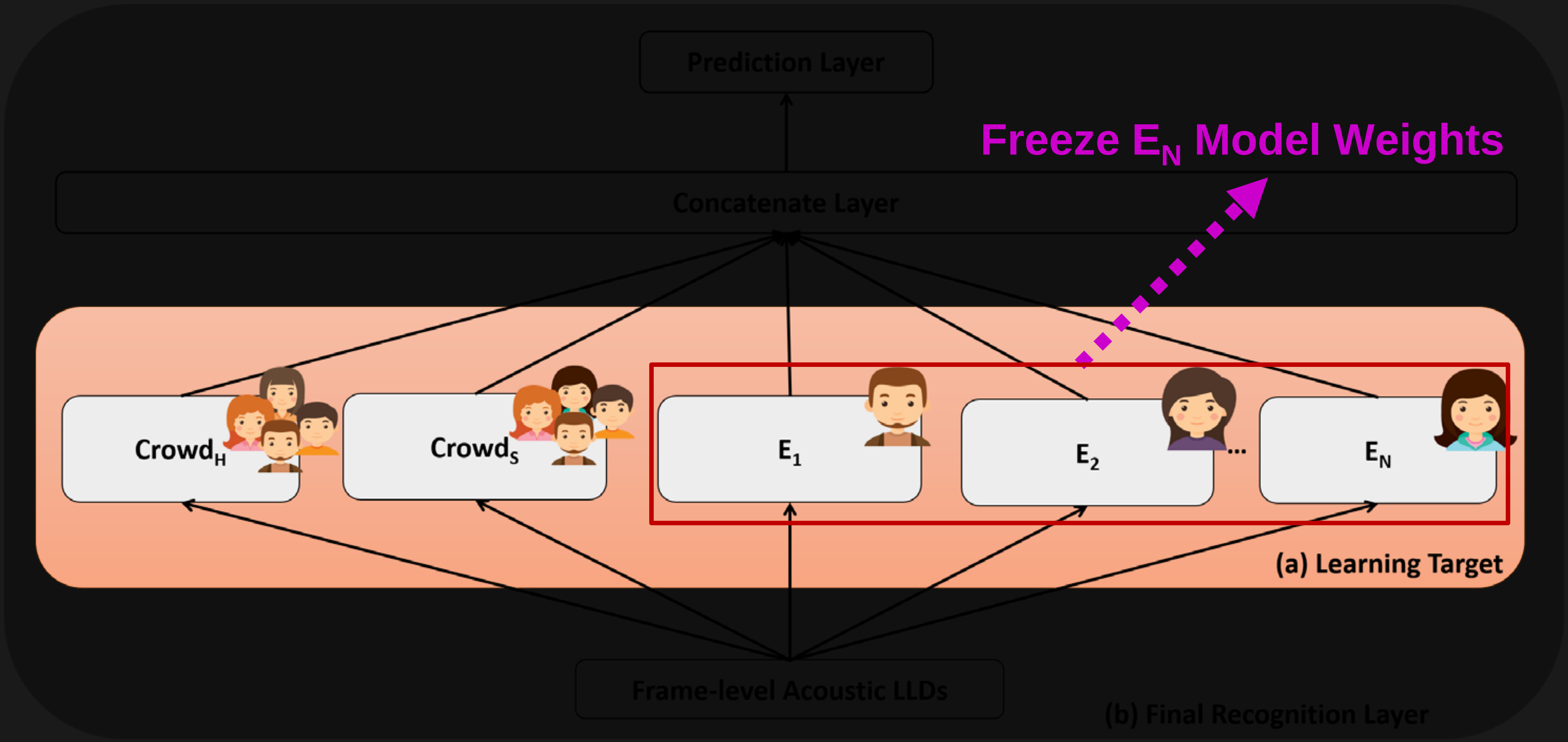
Joint Crowd and E_N



(a) Learning target
(b) Final recognition Layer

Joint Crowd and E_N

Stage-1: Train E_N models and Crowd models

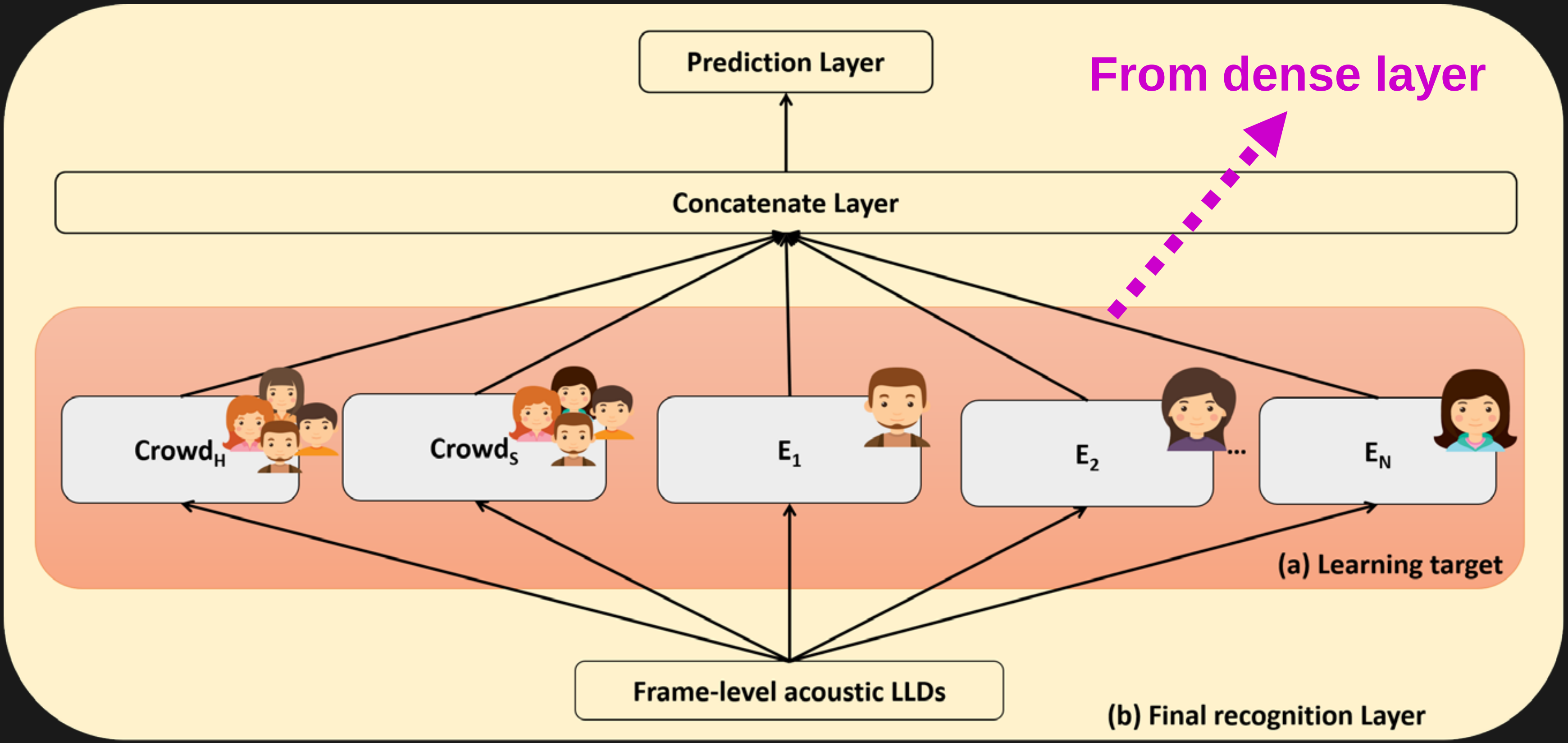


(a) Learning target (b) Final recognition Layer

Joint Crowd and E_N

Stage-1: Train E_N models and Crowd models

Stage-2: Concatenate outputs from dense layer of each model → Train some epochs→ Recognition



(a) Learning target (b) Final recognition Layer

Results

Our proposed model achieves **61.48% UAR**

Model	Overall	Neutral	Anger	Happiness	Sadness
$Crowd_H$	57.45%	55.71%	63.29%	45.02%	65.77%
$Crowd_S$	57.12%	49.70%	62.98%	62.85%	53.14%
E_1	50.98%	8.04%	61.31%	77.24%	57.34%
E_2	59.68%	38.78%	64.35%	64.25%	62.61%
E_4	48.59%	81.29%	45.42%	38.20%	29.44%
E_5	37.62%	86.89%	47.62%	11.21%	4.75%
E_6	45.82%	36.85%	40.10%	60.39%	45.95%
$Crowd_{HS}$	58.58%	59.66%	59.31%	53.63%	61.71%
Proposed	**61.48%**	**54.55%**	**64.51%**	**60.32%**	**66.56%**

Results

$Crowd_S$ obtains a better recognition rate for happiness compared to $Crowd_H$

Model	Overall	Neutral	Anger	Happiness	Sadness
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Results

$\boldsymbol{Crowd_H}$ works better for neutral and sadness than $\boldsymbol{Crowd_S}$

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Results

$E1$ and $E2$ models are good at telling anger and happiness

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Results

For E4 **and** ***E5*** **models, they are good for neutral**

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Results

$E6$ model is sensitive to Happiness

Model	Overall	Neutral	Anger	Happiness	Sadness
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Conclusion

Summary:

- ✓ Purpose: speech emotion classification from acoustic LLDs
- ✓ Approach: Utilizing every rating to model subjective labels and individual annotators
- ✓ Method: Soft-label and hard-label joint learning
- ✓ Results: Performances were improved
  - 57.45% [$Crowd_H$] → 61.48% (**3.18%**)
  - 57.12% [$Crowd_S$] → 61.48% (**4.36%**)

Future works:

- ✓ Evaluations by other language emotion dataset, such as **NNIME** database [Chou+, 2017]
- ✓ Apply on personalized emotion perception recognition

Chou, Huang-Cheng, et al. "NNIME: The NTHU-NTUA Chinese interactive multimodal emotion corpus." 2017 Seventh International Conference on Affective Computing and Intelligent Interaction (ACII). IEEE, 2017.

Thank You

Full Paper: https://ieeexplore.ieee.org/abstract/document/8682170

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Question ?

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Potential Issues - 1

- ✓ Why use soft-label for training but evaluate on hard-label ?
- In this work, we want to follow and compare to the performance of conventional method.
- In some contexts, we can also use other evaluation measures, such as Mean-Square Error (MSE) or Cross Entropy.

Potential Issues - 2

- ✓ Why soft-label training improves model performance?
- Because the training data increased, we get the same finding with previous works [Ando+, 18] and [Kim+, 18].

Ando, Atsushi, et al. "Soft-Target Training with Ambiguous Emotional Utterances for DNN-Based Speech Emotion Classification." 2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). IEEE, 2018.

Kim, Yelin, and Jeesun Kim. "Human-Like Emotion Recognition: Multi-Label Learning from Noisy Labeled Audio-Visual Expressive Speech." 2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). IEEE, 2018.

Potential Issues - 2

- ✓ How is the robustness for modeling individual annotators? If we remove 1 or 2 annotator from training process, does this model can still work?

- It matters because different annotators have different emotional sensitivity to different categories of emotions.
- We model it, and use it to help and improve our robust performance.
- We will study more about this issue in next work.

Ando, Atsushi, et al. "Soft-Target Training with Ambiguous Emotional Utterances for DNN-Based Speech Emotion Classification." 2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). IEEE, 2018.
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Annotation distribution (ratio)

Note: **if two (or more) ratings for one data from annotator, we calculate by 2 (or more).**

Model	Neutral	Anger	Happiness	Sadness
$Crowd_H$	30.88%	19.94%	29.58%	19.60%
$Crowd_S$	29.33%	17.77%	35.79%	17.10%
$\boldsymbol{E1}$	8.49%	21.21%	**49.67%**	20.64%
$\boldsymbol{E2}$	22.45%	26.58%	**31.35%**	19.62%
$\boldsymbol{E4}$	**52.88%**	12.41%	23.76%	10.95%
$\boldsymbol{E5}$	**69.88%**	15.29%	8.94%	5.88%
$\boldsymbol{E6}$	26.73%	15.76%	**43.38%**	14.22%

Results (Only E_N Model)

E_N model is sensitive to Happiness, Anger, and Sadness.
Instead, Crowd models are good for Neutral

Model	Overall	Neutral	Anger	Happiness	Sadness
$Crowd_H$	57.45%	55.71%	63.29%	45.02%	65.77%
$Crowd_S$	57.12%	49.70%	62.98%	62.85%	53.14%
$E1$	50.98%	8.04%	61.31%	77.24%	57.34%
$E2$	59.68%	38.78%	64.35%	64.25%	62.61%
$E4$	48.59%	81.29%	45.42%	38.20%	29.44%
$E5$	37.62%	86.89%	47.62%	11.21%	4.75%
$E6$	45.82%	36.85%	40.10%	60.39%	45.95%
$Crowd_{HS}$	58.58%	59.66%	59.31%	53.63%	61.71%
$\boldsymbol{E_N}$	**60.24%**	**49.64%**	**63.64%**	**61.48%**	**66.19%**
$Proposed$	**61.48%**	54.55%	64.51%	60.32%	66.56%