# ASSIST: Towards Label Noise-Robust Dialogue State Tracking

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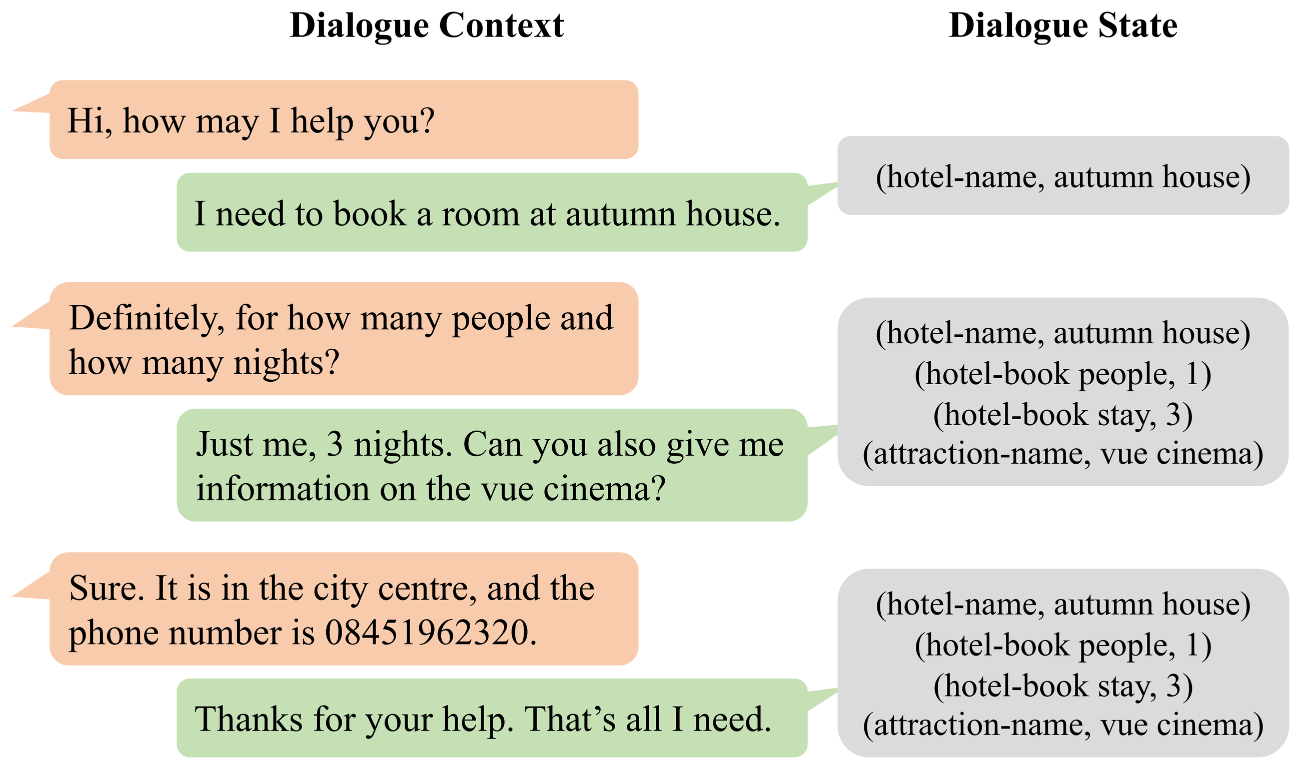
## Introduction & Motivation

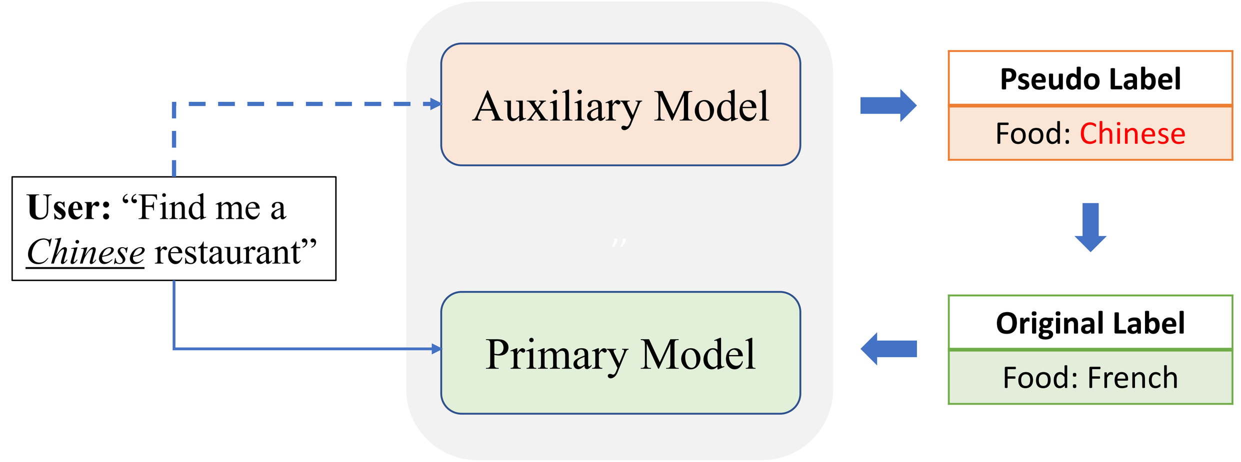
- The dialogue state tracker is an essential component of task-oriented dialogue systems. It aims to keep track of users' intentions at each turn of the conversation




- Dialogue state annotations are error-prone. Without taking noisy annotations into consideration, existing models can only achieve sub-optimal performance
- It is costly and labor-intensive to collect large-scale high-quality dialogue datasets

## Methodology

- We propose a general framework ASSIST to robustly train dialogue state tracking models from noisy labels
- We introduce an auxiliary model, which is trained on a small clean dataset, to generate pseudo labels for each sample in the noisy training set




- We linearly combine the pseudo labels and vanilla labels (their one-hot vector representations) by a parameter $\alpha$

$$\boldsymbol{V}_{combined} = \alpha \boldsymbol{V}_{pseudo} + (1-\alpha)\boldsymbol{V}_{vanilla} \tag{1}$$

- The cross entropy loss objective based on the combined labels can be decomposed into two parts as below

$$\mathcal{L}_{combined} = \alpha \mathcal{L}_{pseudo} + (1-\alpha)\mathcal{L}_{vanilla} \tag{2}$$

## Theoretical Analysis

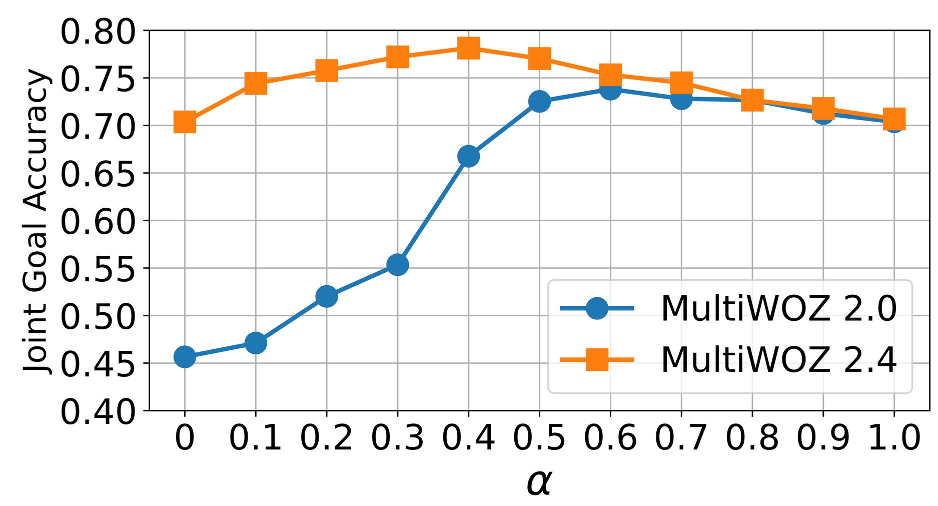
- We define the approximation error of any noisy labels $\boldsymbol{V}_{noisy}$ to the unknown clean labels $\boldsymbol{V}_{clean}$ using mean squared error (MSE)

$$Y_{\boldsymbol{V}_{noisy}} = \frac{1}{|\mathcal{D}_n||\mathcal{S}|}\sum_{\mathcal{X}_t \in \mathcal{D}_n}\sum_{s \in \mathcal{S}} E_{\mathcal{D}_c}[\|\boldsymbol{V}_{noisy} - \boldsymbol{V}_{clean}\|_2^2] \tag{3}$$

- It can be shown that the optimal approximation error with respect to the combined labels $\boldsymbol{V}_{combined}$ is smaller than that of the vanilla labels $\boldsymbol{V}_{vanilla}$ and pseudo labels $\boldsymbol{V}_{pseudo}$, i.e.,

$$\min_{\alpha} Y_{\boldsymbol{V}_{combined}} < \min\{Y_{\boldsymbol{V}_{pseudo}}, Y_{\boldsymbol{V}_{vanilla}}\} \tag{4}$$

- $Y_{\boldsymbol{V}_{combined}}$ is a convex function of $\alpha$




## Experimental Results

- All primary models achieve the best performance when both the vanilla labels and pseudo labels are used for training

| Primary Models | Labels | | MultiWOZ 2.0 | | | MultiWOZ 2.4 | | |
|---|---|---|---|---|---|---|---|---|
| | Vanilla | Pseudo | Joint Goal(%) | Joint Turn(%) | Slot(%) | Joint Goal(%) | Joint Turn(%) | Slot(%) |
| SOM-DST | ✓ | ✗ | 45.14 | 77.86 | 96.71 | 66.78 | 87.81 | 98.38 |
| | ✗ | ✓ | 67.06 | 87.95 | 98.47 | 68.69 | 88.41 | 98.55 |
| | ✓ | ✓ | **70.83** | **89.14** | **98.61** | **75.19** | **91.02** | **98.84** |
| STAR | ✓ | ✗ | 48.30 | 78.91 | 97.10 | 73.62 | 90.45 | 98.85 |
| | ✗ | ✓ | 70.66 | 85.93 | 98.67 | 71.01 | 86.31 | 98.69 |
| | ✓ | ✓ | **74.12** | **88.93** | **98.86** | **79.41** | **91.86** | **99.14** |
| AUX-DST | ✓ | ✗ | 45.66 | 78.76 | 96.95 | 70.37 | 89.31 | 98.67 |
| | ✗ | ✓ | 70.39 | 86.28 | 98.67 | 70.68 | 86.82 | 98.68 |
| | ✓ | ✓ | **73.82** | **88.29** | **98.84** | **78.14** | **91.03** | **99.07** |

- Directly combining the noisy training set with the small clean dataset can also lead to better results, however, the performance improvement is lower than our proposed approach

| Training Settings | Joint Goal (%) MultiWOZ 2.0 | Joint Goal (%) MultiWOZ 2.4 |
|---|---|---|
| Noisy Train | 45.66 | 71.80 |
| Noisy Train + Small Clean | 50.75 | 76.89 |
| Noisy Train + Pseudo Labels | 73.82 | 78.47 |
| Noisy Train + Small Clean + Pseudo Labels | 74.96 | 78.92 |

Paper

- Most slots have lower error rates with the help of the pseudo labels