# Zoom Out and Observe: News Environment Perception for Fake News Detection


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## Why NewsEnv? A Motivating Example

- **Assumption:** A news environment is an **important inspiration of the fabrication** of contemporary fake news, as fake news has to **grab attention** from it.

**Let's observe the NewsEnv as a fake news creator!**


News Environment (containing recent news items) in 2019/11/12~2019/11/14.
Events are differentiated by colors.

## Proposal: Perceive Popularity & Novelty from the NewsEnv

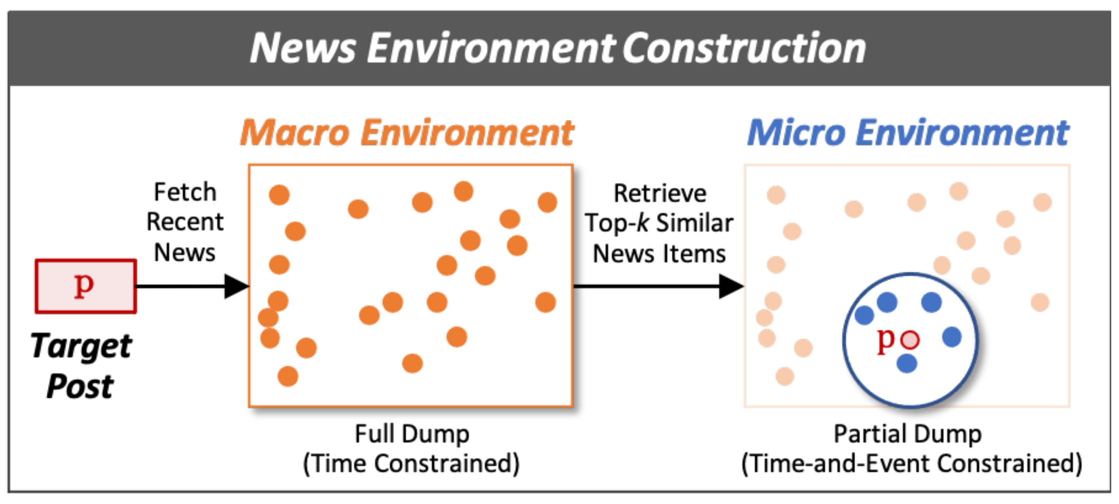
- **Popularity:** Fake news tends to emerge along with **a popular event**, to obtain great exposure and impacts.
- **Novelty:** Fake news often provide **novel side information** for a popular event, to catch audiences' attention and boost the spread.

| | |
|---|---|
| Conventional | $y = p\,(\text{Veracity=fake} \mid \text{Content})$ |
| Ours (Theoretical) | $y = p\,(\text{Veracity=fake} \mid \text{Content, NewsEnv})$ |
| Ours (In Practice) | $y = p\,(\text{Veracity=fake} \mid \text{Content, Popularity/Novelty in NewsEnv})$ |

## NewsEnv Perception (NEP) Framework

### Step 1: NewsEnv Construction

- **MacroEnv:** A full dump of recent news items (say, 3d) from selected outlets to reflect the represent distribution of mainstream focuses.
- **MicroEnv:** Retrieve Top-k similar news items to the target post $p$, to build a event-constrained environment.

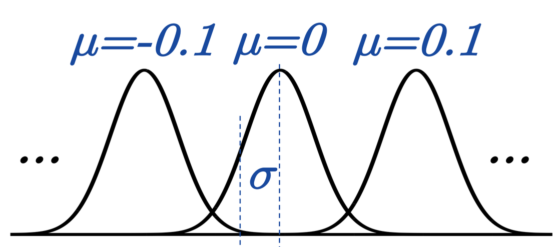



### Step 2: NewsEnv Perception

① **Representation and Similarity Calculation:** Use BERT to obtain vectors and *cosine* similarity to obtain the post-news item similarity.

② **Gaussian Kernel Pooling:** Transform the sim list into a fixed-dim vector.

- **Determine the kernel distribution across [-1,1]**




*Soft Counting*
*when cosine sim→μ, output → 1; otherwise 0*

- **Calculate Gaussian outputs for each kernel. Sum, concat, & norm to obtain the Kernel Output.**

$$\mathbf{K}^i_k = \exp\left(-\frac{(s(\mathbf{p},\mathbf{e}_i)-\mu_k)^2}{2\sigma_k^2}\right) \quad \mathbf{K}_k(\mathbf{p},\mathcal{E}^{mac}) = \sum_{i=1}^{|\mathcal{E}^{mac}|}\mathbf{K}^i_k \quad \mathbf{K}(\mathbf{p},\mathcal{E}^{mac}) = \mathrm{Norm}\left(\bigoplus_{k=1}^{C}\mathbf{K}_k(\mathbf{p},\mathcal{E}^{mac})\right)$$

- **For Popularity-Oriented MacroEnv Perception:** Obtain the Kernel Output for p-$\mathcal{E}^{mac}$.
- **For Novelty-Oriented MicroENv Perception:** Obtain the Kernel Output for p-$\mathcal{E}^{mic}$ & $\mathrm{m}(\mathcal{E}^{mic})$-$\mathcal{E}^{mic}$ (**$\mathrm{m}(\mathcal{E}^{mic})$ is the center vector of MicroEnv).**

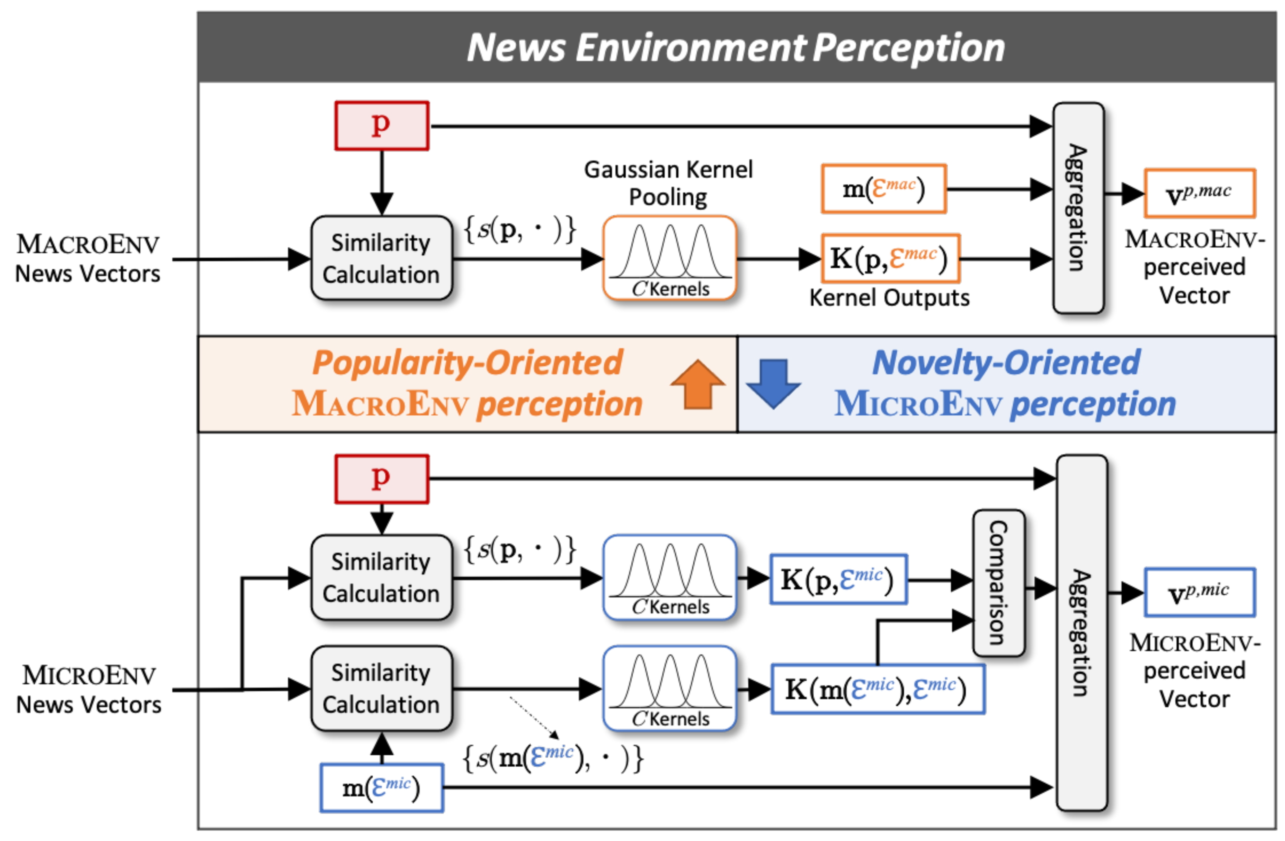
③ **Aggregation:**

- **MacroEnv** $\mathbf{v}^{p,mac} = \mathrm{MLP}(\mathbf{p} \oplus \mathbf{m}(\mathcal{E}^{mac}) \oplus \mathbf{K}(\mathbf{p},\mathcal{E}^{mac}))$
- **MicroENv** $\mathbf{u}^{sem} = \mathrm{MLP}(\mathbf{p} \oplus \mathbf{m}(\mathcal{E}^{mic})),$

$$\mathbf{u}^{sim} = \mathrm{MLP}(\mathrm{g}(\mathbf{K}(\mathbf{p},\mathcal{E}^{mic}),\mathbf{K}(\mathbf{m}(\mathcal{E}^{mic}),\mathcal{E}^{mic}))),$$

$$\mathbf{v}^{p,mic} = \mathrm{MLP}(\mathbf{u}^{sem} \oplus \mathbf{u}^{sim}),$$

where $\mathrm{g}(\mathbf{x},\mathbf{y}) = (\mathbf{x} \odot \mathbf{y}) \oplus (\mathbf{x} - \mathbf{y})$.

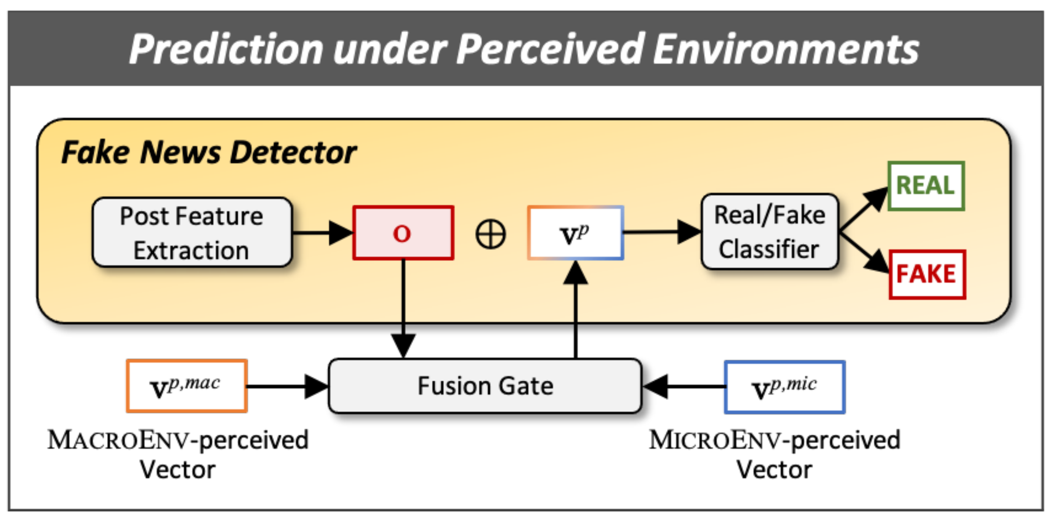



### Step 3: Prediction under Perceived NewsEnv

① **Gate Fusion:** $\mathbf{v}^{p} = \mathbf{g} \odot \mathbf{v}^{p,mac} + (\mathbf{1}-\mathbf{g}) \odot \mathbf{v}^{p,mic}$

$$\mathbf{g} = \mathrm{sigmoid}\,(\mathrm{Linear}\,(\mathbf{o} \oplus \mathbf{v}^{p,mic}))$$

② **Final Prediction:** $\hat{\mathbf{y}} = \mathrm{softmax}(\mathrm{MLP}(\mathbf{o} \oplus \mathbf{v}^{p}))$




## Experiments on New Datasets

**Stats of Datasets** | **News Outlets in NewsEnv**

| Dataset | Chinese Train | Chinese Val | Chinese Test | English Train | English Val | English Test |
|---|---|---|---|---|---|---|
| #Real | 8,787 | 5,131 | 5,625 | 1,976 | 656 | 661 |
| #Fake | 8,992 | 4,923 | 5,608 | 1,924 | 638 | 628 |
| Total | 17,779 | 10,054 | 11,233 | 3,900 | 1,294 | 1,289 |
| #News Items | 583,208 | | | 1,003,646 | | |
| Min/Avg/Max of $\lvert\mathcal{E}^{mac}\rvert$ in 3 days | 41 / 505 / 1,563 | | | 308 / 1,614 / 2,211 | | |

| News Outlet |
|---|
| ***Chinese*** |
| People's Daily |
| Xinhua Agency |
| Xinhua Net |
| CCTV News |
| The Paper |
| Toutiao News |
| ***English*** |
| Huffington Post |
| NPR |
| Daily Mail |

**Performances**

- All six base models see an improvement in terms of Acc. and macF1.

| | Model | Chinese Acc. | Chinese macF1 | Chinese $F1_{fake}$ | Chinese $F1_{real}$ | English Acc. | English macF1 | English $F1_{fake}$ | English $F1_{real}$ |
|---|---|---|---|---|---|---|---|---|---|
| Post-Only | Bi-LSTM | 0.727 | 0.713 | 0.652 | 0.775 | 0.705 | 0.704 | 0.689 | **0.719** |
| | *+NEP* | **0.776** | **0.771** | **0.739** | **0.803** | **0.718** | **0.718** | **0.720** | 0.716 |
| | $EANN_T$ | 0.732 | 0.718 | 0.657 | 0.780 | 0.700 | 0.699 | 0.683 | 0.714 |
| | *+NEP* | **0.776** | **0.770** | **0.733** | **0.807** | **0.722** | **0.722** | **0.722** | **0.722** |
| | BERT | 0.792 | 0.785 | 0.744 | 0.825 | 0.709 | 0.709 | 0.701 | **0.716** |
| | *+NEP* | **0.810** | **0.805** | **0.772** | **0.837** | **0.718** | **0.718** | **0.720** | 0.715 |
| | BERT-Emo | 0.812 | 0.807 | 0.776 | 0.838 | 0.718 | 0.718 | 0.719 | 0.718 |
| | *+NEP* | **0.831** | **0.829** | **0.808** | **0.850** | **0.728** | **0.728** | **0.728** | **0.728** |
| "Zoom-In" | DeClarE | 0.764 | 0.758 | 0.720 | 0.795 | 0.714 | 0.714 | 0.709 | **0.718** |
| | *+NEP* | **0.800** | **0.797** | **0.773** | **0.822** | **0.717** | **0.716** | **0.718** | 0.714 |
| | MAC | 0.755 | 0.751 | 0.717 | 0.784 | 0.706 | 0.705 | 0.708 | 0.701 |
| | *+NEP* | **0.764** | **0.760** | **0.732** | **0.789** | **0.716** | **0.716** | **0.716** | **0.716** |

## Conclusion

- **Problem:** To the best of our knowledge, we are the ***first*** to incorporate news environment perception in fake news detection.
- **Method:** We propose the NEP framework which exploits the perceived signals from the macro and micro news environments of the given post for fake news detection.
- **Data & Experiments:** We construct the ***first*** dataset that includes contemporary main-stream news data for fake news detection. Experiments on offline and online data show the effectiveness of NEP.

**GitHub Repo**