# DeepSI: Interactive Deep Learning for Semantic Interaction

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# Introduction

**Key Focus:**

- Enhancing visual analytics through semantic interaction.
- Integrating deep learning (BERT) into human-in-the-loop pipelines.

**Problem Statement:**

- Traditional Semantic Interaction (SI) systems rely on fixed, pre-trained representations.
- Limited adaptability to user-specific tasks and intents.
- Inefficient user feedback loops for clustering and sensemaking.

# Datasets Overview

| Dataset | Domain | Task Description | Labels/Clusters | Data Size |
|---|---|---|---|---|
| CORD-19 | COVID-19 Research | Group articles by risk factors | 4 (Cancer, Kidney, etc.) | 1,056,660 entries |
| SST (Sentiment Treebank) | Sentiment Analysis | Classify movie reviews into sentiment | 2 (Positive, Negative) | ~1,800 reviews |
| Vispubdata | Academic Papers | Cluster IEEE VIS papers by conference type | 3 (InfoVis, SciVis, VAST) | ~1,400 papers |
| 20 Newsgroups | Text Categorization | Classify news articles by topics | 4 (Autos, Sports, etc.) | ~2,400 articles |

# Framework Overview

- Pre-trained BERT embeddings as initial input.
- Users refine visualizations through feedback.
- Fine-tune BERT using user-driven interaction.
- Generate 2D visualization from BERT embeddings.
- Adjust BERT representations via user feedback (fine-tuning)

# Proposed Solution and Objective

- **DeepSIfinetune:** A framework to improve SI by fine-tuning BERT representations through human feedback.
- Interactive learning that dynamically adapts to user needs.
- Task-specific, user-driven data representations.
- Enhanced accuracy and efficiency in SI systems.
- Application to real-world datasets (e.g., COVID-19 research).

# How It Works

**Initial Data Representation:**

- Uses pre-trained BERT embeddings to initialize data representations.
- Data is visualized in a scatterplot based on these embeddings using MDS (Multidimensional Scaling).

**User Interaction:**

- Users adjust data points by clustering them visually (e.g., dragging articles into groups).

**Model Fine-Tuning:**

- User feedback triggers backpropagation to fine-tune BERT representations dynamically.
- This generates task-specific representations that reflect user-defined relationships.

**Feedback Loop:**

- Updated model generates new, refined visualizations, better aligned with user goals.

**Comparison to Baseline (DeepSIvanilla):**

- DeepSIfinetune embeds fine-tuning directly into the interaction pipeline, while DeepSIvanilla relies on static pre-trained embeddings, limiting adaptability.

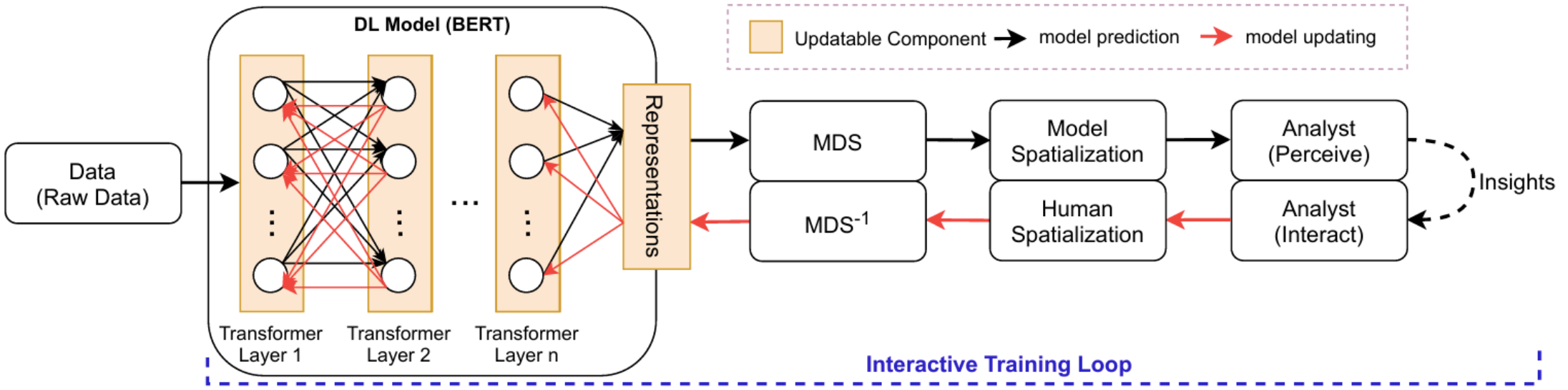



**Figure 4: DeepSI$_{\text{finetune}}$ pipeline: embedding BERT within the SI loop. Semantic interactions are exploited to fine-tune BERT interactively through backpropagation. The tuned BERT is responsible for generating new representations, so as to capture the analyst's intent. Thereby, no external parameters are needed.**


**Figure 5: Screenshots during the case study using DeepSI$_{vanilla}$: Frame 1 and 2 show the similar initial steps performed by the analyst in Fig. 1. Frame 3 shows the resulting projection updated by DeepSI$_{vanilla}$.**


**Figure 6: Further case study using DeepSI$_{vanilla}$ in grouping two clusters: Frame 1 is the initial projection layout, Frame 2 shows interactions performed within the projection, and Frame 3 shows the resulting projection updated by DeepSI$_{vanilla}$.**

# Why is This Problem Relevant?

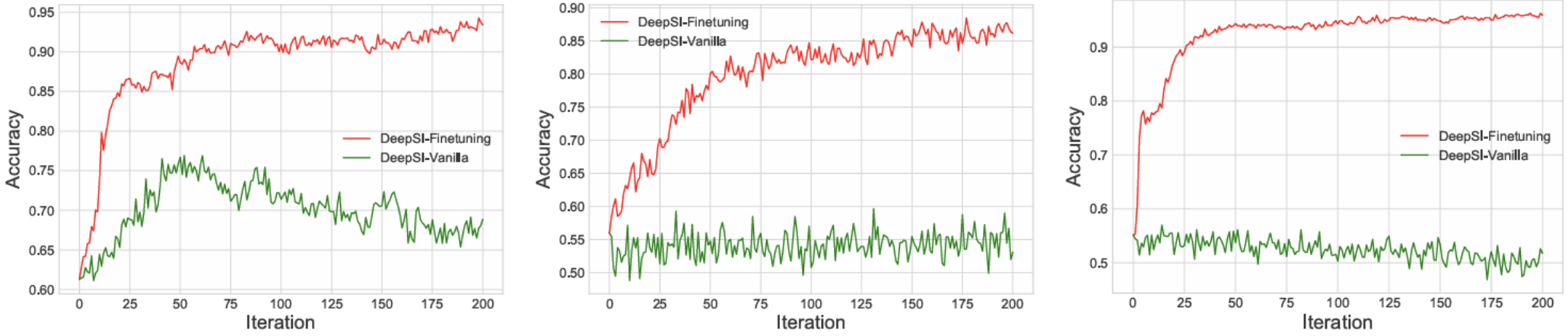
- Increasing complexity and volume of data require intuitive, interactive systems for sensemaking.
- Static models (e.g., pre-trained features) fail to capture user-specific and task-specific nuances.
- Efficient feedback loops reduce cognitive and interactional burden.
- Adapts to diverse domains with minimal user effort.

# Bottlenecks and Limitations

| Category | Limitation |
| --- | --- |
| Model Dependence | Relies heavily on the quality of pretrained BERT embeddings. |
| Computational Complexity | Fine-tuning BERT and MDS scaling are resource-intensive, especially for large datasets. |
| Interpretability | Lack of transparency in how internal model updates align with user feedback. |
| Scalability | Challenges in adapting to very large datasets and non-textual data domains. |
| User Dependency | Relies on high-quality user feedback; effectiveness depends on user expertise. |

# Justification of Accuracy






(a) $T_{sst}$ (b) $T_{vis}$ (c) $T_{news}$

**Figure 8: The accuracies of both $DeepSI_{finetune}$ and $DeepSI_{vanilla}$ updated projections over 200 iterations across the three tasks ($T_{sst}$, $T_{vis}$, and $T_{news}$) during the simulation-based experiment.**

# Thank you

# Q&A