# MSAI 508 – Natural Language Processing

**Assignment #3: Identify Keywords, Search for RRL and make Matrix.**

1. **RESEARCH TOPIC**

*A Deep Learning Approach to Solving Inverse Kinematics for an Educational 6-DOF Articulated Manipulator*

1. **KEYWORDS and SYNONYMS SEARCH FOR RELEVANT LITERATURE WITH BOOLEAN OPERATORS**

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| **KEYWORDS SEARCH** | **Year Range** | **NUMBER OF HITS** |
| **General Sentiment Analysis Terms** |  |  |
| ("Sentiment Analysis" OR "Opinion Mining" OR "Subjectivity Analysis" OR "Emotion Detection" OR "Sentiment Classification") | 2019 -2025 | **17,000** |
| **Methods & Techniques** |  |  |
| ("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis") | 2019 -2025 | **5,190** |
| ("Machine Learning" AND "Sentiment Analysis") | 2019 -2025 | **163,000** |
| ("Deep Learning" AND "Sentiment Analysis") | 2019 -2025 | **56,600** |
| ("Transformer-based Sentiment Analysis" OR "BERT" OR "GPT" OR "XLNet") | 2019 -2025 | **287,000** |
| ("Neural Networks" AND "Sentiment Classification") | 2019 -2025 | **25,800** |
| ("Sentiment Polarity Detection" OR "Aspect-based Sentiment Analysis") | 2019 -2025 | **16,400** |
| **Natural Language Processing (NLP) in Sentiment Analysis** |  |  |
| ("Tokenization" OR "Named Entity Recognition" OR "NER" OR "Text Preprocessing" OR "Stopword Removal") | 2019 -2025 | **175,000** |
| ("Part-of-Speech Tagging" OR "POS Tagging") | 2019 -2025 | **17,400** |
| ("Word Embeddings" AND ("Word2Vec" OR "GloVe" OR "FastText")) | 2019 -2025 | **28,900** |
| ("TF-IDF" OR "Term Frequency-Inverse Document Frequency") | 2019 -2025 | **17,400** |
| ("BERT" OR "LSTM" OR "Transformers") | 2019 -2025 | **691,000** |
| **Datasets & Resources** |  |  |
| ("IMDB Sentiment Dataset" OR "Twitter Sentiment Analysis" OR "Amazon Reviews Sentiment Dataset") | 2019 -2025 | **15,500** |
| ("Yelp Reviews Sentiment Dataset" OR "Sentiment140" OR "SentiWordNet" OR "VADER") | 2019 -2025 | **41,500** |
| **Evaluation Metrics** |  |  |
| ("Accuracy" OR "Precision" OR "Recall" OR "F1-score") | 2019 -2025 | **41,500** |
| ("ROC-AUC Curve" OR "Confusion Matrix") | 2019 -2025 | **16,300** |
| **Challenges & Open Research Areas** |  |  |
| ("Sarcasm Detection" OR "Contextual Sentiment Understanding") | 2019 -2025 | **6,950** |
| ("Multilingual Sentiment Analysis" OR "Code-Mixed Sentiment Analysis") | 2019 -2025 | **2,880** |
| ("Fake Review Detection" OR "Domain Adaptation in Sentiment Analysis") | 2019 -2025 | **2,250** |

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| **KEYWORDS SEARCH** | **Year Range** | **NUMBER OF HITS** |
| **General Sentiment Analysis Terms** |  |  |
| ("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis") AND ("Hybrid Models" OR "Deep Learning Integration") NOT ("2010" OR "2005") | 2019 -2025 | **129** |
| **Methods & Techniques** |  |  |
| ("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis") AND ("Hybrid Models" OR "Deep Learning Integration") NOT ("2010" OR "2005") | 2019 -2025 | **129** |
| ("Machine Learning" AND "Sentiment Analysis") AND ("Neural Networks" OR "Deep Learning") NOT ("SVM" OR "Naïve Bayes" OR "Decision Trees") | 2019 -2025 | **17,700** |
| ("Deep Learning" AND "Sentiment Analysis") AND ("BERT" OR "GPT" OR "LSTM") NOT ("SVM" OR "Naïve Bayes") | 2019 -2025 | **17,900** |
| ("Deep Learning" AND "Sentiment Analysis") AND ("BERT" OR "GPT" OR "LSTM") NOT ("SVM" OR "Naïve Bayes") | 2019 -2025 | **17,900** |
| ("Transformer-based Sentiment Analysis" OR "BERT" OR "GPT" OR "XLNet") AND ("fine-tuning" OR "pre-trained models") NOT ("traditional ML" OR "TF-IDF") | 2019 -2025 | **16,700** |
| ("Neural Networks" AND "Sentiment Classification") AND ("Transformer" OR "Attention Mechanisms") NOT ("Basic RNN" OR "Traditional ML") | 2019 -2025 | **738** |
| ("Sentiment Polarity Detection" OR "Aspect-based Sentiment Analysis") AND ("BERT" OR "Fine-tuned Models") NOT ("Lexicon-based" OR "SVM") | 2019 -2025 | **4,570** |
| **Natural Language Processing (NLP) in Sentiment Analysis** |  |  |
| ("Tokenization" OR "Named Entity Recognition" OR "NER" OR "Text Preprocessing" OR "Stopword Removal") AND ("Sentiment Analysis" OR "BERT") NOT ("Topic Modeling" OR "Summarization") | 2019 -2025 | **17,600** |
| ("Part-of-Speech Tagging" OR "POS Tagging") AND ("Sentiment Analysis") NOT ("Parsing" OR "Linguistics") | 2019 -2025 | **14,500** |
| ("Word Embeddings" AND ("Word2Vec" OR "GloVe" OR "FastText")) AND ("Transformer Models" OR "Pre-trained Models") NOT ("TF-IDF") | 2019 -2025 | **5,410** |
| ("TF-IDF" OR "Term Frequency-Inverse Document Frequency") AND ("Neural Networks" OR "Deep Learning") NOT ("Naïve Bayes" OR "SVM") | 2019 -2025 | **17,500** |
| ("BERT" OR "LSTM" OR "Transformers") AND ("Sentiment Analysis" OR "Fine-tuning") NOT ("TF-IDF" OR "Lexicon-based") | 2019 -2025 | **17,600** |
| **Datasets & Resources** |  |  |
| ("IMDB Sentiment Dataset" OR "Twitter Sentiment Analysis" OR "Amazon Reviews Sentiment Dataset") AND ("Real-world Applications" OR "Benchmark") NOT ("Synthetic Dataset" OR "Small Dataset") | 2019 -2025 | **267** |
| ("Yelp Reviews Sentiment Dataset" OR "Sentiment140" OR "SentiWordNet" OR "VADER") AND ("Deep Learning Applications") NOT ("Simple Lexicon-based Methods") | 2019 -2025 | **0** |
| **Evaluation Metrics** |  |  |
| ("Accuracy" OR "Precision" OR "Recall" OR "F1-score") AND ("Deep Learning" OR "Transformer Models") NOT ("Traditional ML" OR "Lexicon-based") | 2019 -2025 | **17,600** |
| ("ROC-AUC Curve" OR "Confusion Matrix") AND ("Neural Networks" OR "Sentiment Analysis") NOT ("Naïve Bayes" OR "SVM") | 2019 -2025 | **17,800** |
| **Challenges & Open Research Areas** |  |  |
| ("Sarcasm Detection" OR "Contextual Sentiment Understanding") AND ("Transformer-based" OR "BERT") NOT ("Rule-based" OR "Lexicon-based") | 2019 -2025 | **1,300** |
| ("Multilingual Sentiment Analysis" OR "Code-Mixed Sentiment Analysis") AND ("Low-resource Languages" OR "Transfer Learning") NOT ("English-only" OR "Simple Classification") | 2019 -2025 | **34** |
| ("Fake Review Detection" OR "Domain Adaptation") AND ("Real-world Implementation" OR "Transformer Models") NOT ("Basic Classification" OR "Synthetic Dataset") | 2019 -2025 | **265** |

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| **KEYWORDS SEARCH** | **Year Range** | **NUMBER OF HITS** |
| **General Sentiment Analysis Terms** |  |  |
| **("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis") AND ("Hybrid Models" OR "Deep Learning Integration") AND ("Recent Advances" OR "Real-world Applications") NOT ("2010" OR "2005" OR "TF-IDF" OR "Naïve Bayes")** | 2019 -2025 | **49** |
| **Methods & Techniques** |  |  |
| ("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis") AND ("Deep Learning Integration" OR "Transformer-based Models") NOT ("TF-IDF" OR "2010" OR "2005" OR "Bag of Words") | 2019 -2025 | **214** |
| ("Machine Learning" AND "Sentiment Analysis") AND ("Neural Networks" OR "Deep Learning") AND ("State-of-the-Art" OR "Recent Progress") NOT ("SVM" OR "Naïve Bayes" OR "Decision Trees") | 2019 -2025 | **17,500** |
| ("Deep Learning" AND "Sentiment Analysis") AND ("BERT" OR "GPT" OR "LSTM" OR "XLNet") AND ("Pre-trained Models" OR "Fine-tuning") NOT ("SVM" OR "Naïve Bayes" OR "TF-IDF") | 2019 -2025 | **16,000** |
| ("Transformer-based Sentiment Analysis" OR "BERT" OR "GPT" OR "XLNet") AND ("Fine-tuning" OR "Zero-shot Learning") NOT ("TF-IDF" OR "Traditional ML") | 2019 -2025 | **16,400** |
| ("Neural Networks" AND "Sentiment Classification") AND ("Transformer" OR "Attention Mechanisms") AND ("Advanced Architectures" OR "Performance Evaluation") NOT ("Basic RNN" OR "Traditional ML") | 2019 -2025 | **220** |
| ("Sentiment Polarity Detection" OR "Aspect-based Sentiment Analysis") AND ("BERT" OR "Fine-tuned Models" OR "Attention Mechanisms") NOT ("Lexicon-based" OR "SVM" OR "Naïve Bayes") | 2019 -2025 | **5,030** |
| **Natural Language Processing (NLP) in Sentiment Analysis** |  |  |
| ("Tokenization" OR "Named Entity Recognition" OR "NER" OR "Text Preprocessing" OR "Stopword Removal") AND ("Sentiment Analysis" OR "BERT") AND ("Performance Impact" OR "Efficiency") NOT ("Topic Modeling" OR "Summarization") | 2019 -2025 | **16,400** |
| ("Part-of-Speech Tagging" OR "POS Tagging") AND ("Sentiment Analysis") AND ("Dependency Parsing" OR "Context-aware Analysis") NOT ("Basic Parsing" OR "Linguistics-only") | 2019 -2025 | **2** |
| ("Word Embeddings" AND ("Word2Vec" OR "GloVe" OR "FastText")) AND ("Transformer Models" OR "Contextual Representations") NOT ("TF-IDF" OR "Bag of Words") | 2019 -2025 | **4,620** |
| ("TF-IDF" OR "Term Frequency-Inverse Document Frequency") AND ("Neural Networks" OR "Deep Learning") AND ("Hybrid Approaches" OR "Comparison Studies") NOT ("Naïve Bayes" OR "SVM") | 2019 -2025 | **1,960** |
| ("BERT" OR "LSTM" OR "Transformers") AND ("Sentiment Analysis" OR "Fine-tuning") AND ("Recent Developments" OR "Performance Comparison") NOT ("TF-IDF" OR "Lexicon-based") | 2019 -2025 | **6,000** |
| **Datasets & Resources** |  |  |
| ("IMDB Sentiment Dataset" OR "Twitter Sentiment Analysis" OR "Amazon Reviews Sentiment Dataset") AND ("Benchmark Studies" OR "Real-world Performance") NOT ("Synthetic Dataset" OR "Toy Dataset") | 2019 -2025 | **2** |
| **Evaluation Metrics** |  |  |
| ("Accuracy" OR "Precision" OR "Recall" OR "F1-score") AND ("Deep Learning" OR "Transformer Models") AND ("Robust Evaluation" OR "Performance Benchmarking") NOT ("Traditional ML" OR "Lexicon-based") | 2019 -2025 | **614** |
| ("ROC-AUC Curve" OR "Confusion Matrix") AND ("Neural Networks" OR "Sentiment Analysis") AND ("Transformer-based Models") NOT ("Naïve Bayes" OR "SVM") | 2019 -2025 | **2,290** |
| **Challenges & Open Research Areas** |  |  |
| ("Sarcasm Detection" OR "Contextual Sentiment Understanding") AND ("Transformer-based" OR "BERT" OR "Zero-shot Learning") AND ("Future Research Directions") NOT ("Rule-based" OR "Lexicon-based") | 2019 -2025 | 149 |
| ("Multilingual Sentiment Analysis" OR "Code-Mixed Sentiment Analysis") AND ("Low-resource Languages" OR "Cross-lingual Transfer") NOT ("English-only" OR "Simple Classification") | 2019 -2025 | 25 |
| ("Fake Review Detection" OR "Domain Adaptation") AND ("Real-world Implementation" OR "Transformer Models") AND ("Adversarial Learning" OR "Transfer Learning") NOT ("Basic Classification" OR "Synthetic Dataset") | 2019 -2025 | **175** |

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| **KEYWORDS SEARCH** | **Year Range** | **NUMBER OF HITS** |
| **General Sentiment Analysis Terms** |  |  |
| ("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis") AND ("Hybrid Models" OR "Deep Learning Integration") AND ("Recent Advances" OR "Real-world Applications") NOT ("2010" OR "2005" OR "TF-IDF" OR "Naïve Bayes") | 2019 -2025 | **49** |
| **Methods & Techniques** |  |  |
| ("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis")  AND ("Deep Learning Integration" OR "Transformer-based Models")  AND ("Hybrid Approaches" OR "State-of-the-Art")  NOT ("TF-IDF" OR "Bag of Words" OR "2010" OR "2005") | 2019 -2025 | **168** |
| ("Machine Learning" AND "Sentiment Analysis")  AND ("Neural Networks" OR "Deep Learning")  AND ("Advancements" OR "Breakthroughs")  NOT ("SVM" OR "Naïve Bayes" OR "Decision Trees") | 2019 -2025 | **16,500** |
| ("Deep Learning" AND "Sentiment Analysis")  AND ("BERT" OR "GPT" OR "LSTM" OR "XLNet")  AND ("Pre-trained Models" OR "Fine-tuning" OR "Zero-shot Learning")  NOT ("SVM" OR "Naïve Bayes" OR "TF-IDF") | 2019 -2025 | **16.100** |
| ("Transformer-based Sentiment Analysis" OR "BERT" OR "GPT" OR "XLNet")  AND ("Fine-tuning" OR "Zero-shot Learning")  AND ("Recent Developments" OR "Industrial Applications")  NOT ("TF-IDF" OR "Traditional ML") | 2019 -2025 | **1,220** |
| ("Neural Networks" AND "Sentiment Classification")  AND ("Transformer" OR "Attention Mechanisms")  AND ("Optimization Techniques" OR "Performance Metrics")  NOT ("Basic RNN" OR "Traditional ML") | 2019 -2025 | **288** |
| ("Sentiment Polarity Detection" OR "Aspect-based Sentiment Analysis")  AND ("BERT" OR "Fine-tuned Models" OR "Attention Mechanisms")  AND ("Context-aware Models" OR "Evaluation Benchmarks")  NOT ("Lexicon-based" OR "SVM" OR "Naïve Bayes") | 2019 -2025 | **63** |
| **Natural Language Processing (NLP) in Sentiment Analysis** |  |  |
| ("Tokenization" OR "Named Entity Recognition" OR "NER" OR "Text Preprocessing" OR "Stopword Removal")  AND ("Sentiment Analysis" OR "BERT")  AND ("Efficiency" OR "Computational Performance")  NOT ("Topic Modeling" OR "Summarization") | 2019 -2025 | **16,400** |
| ("Part-of-Speech Tagging" OR "POS Tagging") AND ("Sentiment Analysis") AND ("Dependency Parsing" OR "Context-aware Analysis") NOT ("Basic Parsing" OR "Linguistics-only") | 2019 -2025 | **2** |
| ("Word Embeddings" AND ("Word2Vec" OR "GloVe" OR "FastText"))  AND ("Transformer Models" OR "Contextual Representations")  AND ("Impact on Sentiment Analysis")  NOT ("TF-IDF" OR "Bag of Words") | 2019 -2025 | **10** |
| ("TF-IDF" OR "Term Frequency-Inverse Document Frequency")  AND ("Neural Networks" OR "Deep Learning")  AND ("Hybrid Approaches" OR "Benchmark Comparisons")  NOT ("Naïve Bayes" OR "SVM") | 2019 -2025 | **1920** |
| ("BERT" OR "LSTM" OR "Transformers")  AND ("Sentiment Analysis" OR "Fine-tuning")  AND ("Comparative Studies" OR "Optimization Strategies")  NOT ("TF-IDF" OR "Lexicon-based") | 2019 -2025 | **991** |
| **Datasets & Resources** |  |  |
| ("IMDB Sentiment Dataset" OR "Twitter Sentiment Analysis" OR "Amazon Reviews Sentiment Dataset") AND ("Benchmark Studies" OR "Real-world Performance") NOT ("Synthetic Dataset" OR "Toy Dataset") | 2019 -2025 | **2** |
| **Evaluation Metrics** |  |  |
| ("Accuracy" OR "Precision" OR "Recall" OR "F1-score")  AND ("Deep Learning" OR "Transformer Models")  AND ("Performance Benchmarking" OR "Optimization Strategies")  NOT ("Traditional ML" OR "Lexicon-based") | 2019 -2025 | **903** |
| ("ROC-AUC Curve" OR "Confusion Matrix")  AND ("Neural Networks" OR "Sentiment Analysis")  AND ("Transformer-based Models" OR "Adversarial Testing")  NOT ("Naïve Bayes" OR "SVM") | 2019 -2025 | **2,340** |
| **Challenges & Open Research Areas** |  |  |
| ("Sarcasm Detection" OR "Contextual Sentiment Understanding")  AND ("Transformer-based" OR "BERT" OR "Zero-shot Learning")  AND ("Emerging Challenges" OR "Performance Bottlenecks")  NOT ("Rule-based" OR "Lexicon-based") | 2019 -2025 | 9 |
| ("Multilingual Sentiment Analysis" OR "Code-Mixed Sentiment Analysis") AND ("Low-resource Languages" OR "Cross-lingual Transfer") NOT ("English-only" OR "Simple Classification") | 2019 -2025 | 25 |
| ("Fake Review Detection" OR "Domain Adaptation")  AND ("Real-world Implementation" OR "Transformer Models")  AND ("Cross-domain Generalization" OR "Adversarial Learning")  NOT ("Basic Classification" OR "Synthetic Dataset") | 2019 -2025 | **44** |

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| **KEYWORDS SEARCH** | **Year Range** | **NUMBER OF HITS** |
| **General Sentiment Analysis Terms** |  |  |
| ("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis") AND ("Hybrid Models" OR "Deep Learning Integration") AND ("Recent Advances" OR "Real-world Applications") NOT ("2010" OR "2005" OR "TF-IDF" OR "Naïve Bayes") | 2019 -2025 | **49** |
| **Methods & Techniques** |  |  |
| ("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis")  AND ("Deep Learning Integration" OR "Transformer-based Models")  AND ("Hybrid Approaches" OR "State-of-the-Art" OR "Recent Advances")  NOT ("TF-IDF" OR "Bag of Words" OR "2010" OR "2005") | 2019 -2025 | **171** |
| ("Machine Learning" AND "Sentiment Analysis")  AND ("Neural Networks" OR "Deep Learning")  AND ("Breakthroughs" OR "Recent Trends" OR "Cutting-edge Techniques")  NOT ("SVM" OR "Naïve Bayes" OR "Decision Trees" OR "Traditional ML") | 2019 -2025 | **6,950** |
| ("Deep Learning" AND "Sentiment Analysis")  AND ("BERT" OR "GPT" OR "LSTM" OR "XLNet")  AND ("Pre-trained Models" OR "Fine-tuning" OR "Zero-shot Learning" OR "Few-shot Learning")  NOT ("SVM" OR "Naïve Bayes" OR "TF-IDF") | 2019 -2025 | **16,300** |
| ("Transformer-based Sentiment Analysis" OR "BERT" OR "GPT" OR "XLNet")  AND ("Fine-tuning" OR "Zero-shot Learning" OR "Self-supervised Learning")  AND ("Recent Developments" OR "Real-world Applications" OR "Domain Adaptation")  NOT ("TF-IDF" OR "Traditional ML" OR "Bag of Words") | 2019 -2025 | **6,920** |
| ("Neural Networks" AND "Sentiment Classification")  AND ("Transformer" OR "Attention Mechanisms" OR "Self-attention")  AND ("Optimization Techniques" OR "Performance Metrics" OR "Scalability")  NOT ("Basic RNN" OR "Traditional ML") | 2019 -2025 | **374** |
| ("Sentiment Polarity Detection" OR "Aspect-based Sentiment Analysis")  AND ("BERT" OR "Fine-tuned Models" OR "Attention Mechanisms")  AND ("Context-aware Models" OR "Evaluation Benchmarks")  NOT ("Lexicon-based" OR "SVM" OR "Naïve Bayes") | 2019 -2025 | **63** |
| **Natural Language Processing (NLP) in Sentiment Analysis** |  |  |
| ("Tokenization" OR "Named Entity Recognition" OR "NER" OR "Text Preprocessing" OR "Stopword Removal")  AND ("Sentiment Analysis" OR "BERT")  AND ("Efficiency" OR "Computational Performance" OR "Data Augmentation")  NOT ("Topic Modeling" OR "Summarization" OR "Bag of Words") | 2019 -2025 | **17,300** |
| ("Part-of-Speech Tagging" OR "POS Tagging") AND ("Sentiment Analysis") AND ("Dependency Parsing" OR "Context-aware Analysis") NOT ("Basic Parsing" OR "Linguistics-only") | 2019 -2025 | **2** |
| ("Word Embeddings" AND ("Word2Vec" OR "GloVe" OR "FastText"))  AND ("Transformer Models" OR "Contextual Representations")  AND ("Impact on Sentiment Analysis")  NOT ("TF-IDF" OR "Bag of Words") | 2019 -2025 | **10** |
| ("TF-IDF" OR "Term Frequency-Inverse Document Frequency")  AND ("Neural Networks" OR "Deep Learning")  AND ("Hybrid Approaches" OR "Benchmark Comparisons" OR "Feature Selection")  NOT ("Naïve Bayes" OR "SVM") | 2019 -2025 | **14,900** |
| ("BERT" OR "LSTM" OR "Transformers")  AND ("Sentiment Analysis" OR "Fine-tuning")  AND ("Comparative Studies" OR "Optimization Strategies" OR "Cross-domain Generalization")  NOT ("TF-IDF" OR "Lexicon-based" OR "Rule-based") | 2019 -2025 | **2,180** |
| **Datasets & Resources** |  |  |
| ("IMDB Sentiment Dataset" OR "Twitter Sentiment Analysis" OR "Amazon Reviews Sentiment Dataset") AND ("Benchmark Studies" OR "Real-world Performance") NOT ("Synthetic Dataset" OR "Toy Dataset") | 2019 -2025 | **2** |
| **Evaluation Metrics** |  |  |
| ("Accuracy" OR "Precision" OR "Recall" OR "F1-score")  AND ("Deep Learning" OR "Transformer Models")  AND ("Performance Benchmarking" OR "Optimization Strategies" OR "Error Analysis")  NOT ("Traditional ML" OR "Lexicon-based" OR "Bag of Words") | 2019 -2025 | **4,570** |
| ("ROC-AUC Curve" OR "Confusion Matrix")  AND ("Neural Networks" OR "Sentiment Analysis")  AND ("Transformer-based Models" OR "Adversarial Testing" OR "Robustness Analysis")  NOT ("Naïve Bayes" OR "SVM") | 2019 -2025 | **2,750** |
| **Challenges & Open Research Areas** |  |  |
| ("Sarcasm Detection" OR "Contextual Sentiment Understanding")  AND ("Transformer-based" OR "BERT" OR "Zero-shot Learning")  AND ("Emerging Challenges" OR "Performance Bottlenecks")  NOT ("Rule-based" OR "Lexicon-based") | 2019 -2025 | 9 |
| ("Multilingual Sentiment Analysis" OR "Code-Mixed Sentiment Analysis") AND ("Low-resource Languages" OR "Cross-lingual Transfer") NOT ("English-only" OR "Simple Classification") | 2019 -2025 | 25 |
| ("Fake Review Detection" OR "Domain Adaptation")  AND ("Real-world Implementation" OR "Transformer Models")  AND ("Cross-domain Generalization" OR "Adversarial Learning")  NOT ("Basic Classification" OR "Synthetic Dataset") | 2019 -2025 | **44** |

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| **KEYWORDS SEARCH** | **Year Range** | **NUMBER OF HITS** |
| **General Sentiment Analysis Terms** |  |  |
| ("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis") AND ("Hybrid Models" OR "Deep Learning Integration") AND ("Recent Advances" OR "Real-world Applications") NOT ("2010" OR "2005" OR "TF-IDF" OR "Naïve Bayes") | 2019 -2025 | **49** |
| **Methods & Techniques** |  |  |
| ("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis")  AND ("Deep Learning Integration" OR "Transformer-based Models")  AND ("Hybrid Approaches" OR "Real-world Case Studies")  AND ("Financial Sentiment" OR "Medical Sentiment")  NOT ("TF-IDF" OR "Bag of Words" OR "2010" OR "2005" OR "Survey") | 2019 -2025 | **4** |
| ("Machine Learning" AND "Sentiment Analysis")  AND ("Neural Networks" OR "Deep Learning")  AND ("Contrastive Learning with Self-Supervised Training")  AND ("Financial Text Classification on Arabic Tweets")  AND ("Benchmarking on Financial Sentiment Dataset")  NOT ("SVM" OR "Naïve Bayes" OR "Decision Trees" OR "Traditional ML" OR "Review Paper") | 2019 -2025 | **0** |
| ("Deep Learning" AND "Sentiment Analysis")  AND ("BERT" OR "GPT-4" OR "LSTM" OR "XLNet")  AND ("Few-shot Learning" OR "Contrastive Learning")  AND ("Financial Text" OR "Legal Text Analysis")  NOT ("SVM" OR "Naïve Bayes" OR "TF-IDF" OR "General Reviews") | 2019 -2025 | **84** |
| ("Transformer-based Sentiment Analysis" OR "BERT" OR "GPT" OR "XLNet")  AND ("Fine-tuning" OR "Zero-shot Learning")  AND ("Cross-lingual Applications" OR "Low-resource Languages")  AND ("Multilingual Performance Benchmarking")  NOT ("TF-IDF" OR "Traditional ML" OR "Bag of Words" OR "English-only") | 2019 -2025 | **0** |
| ("Neural Networks" AND "Sentiment Classification")  AND ("Transformer" OR "Attention Mechanisms")  AND ("Optimization Techniques" OR "Low-latency Models")  AND ("Mobile Applications" OR "Edge AI")  NOT ("Basic RNN" OR "Traditional ML") | 2019 -2025 | **7** |
| ("Sentiment Polarity Detection" OR "Aspect-based Sentiment Analysis")  AND ("BERT" OR "Fine-tuned Models" OR "Attention Mechanisms")  AND ("Context-aware Models" OR "Evaluation Benchmarks")  NOT ("Lexicon-based" OR "SVM" OR "Naïve Bayes") | 2019 -2025 | **63** |
| **Natural Language Processing (NLP) in Sentiment Analysis** |  |  |
| ("Tokenization" OR "Named Entity Recognition" OR "NER" OR "Text Preprocessing")  AND ("Sentiment Analysis")  AND ("Few-shot Learning for Multilingual Twitter Data")  AND ("Tigrinya or Amharic Language Sentiment Analysis")  NOT ("Topic Modeling" OR "Summarization" OR "Bag of Words" OR "High-resource English") | 2019 -2025 | **0** |
| ("Part-of-Speech Tagging" OR "POS Tagging") AND ("Sentiment Analysis") AND ("Dependency Parsing" OR "Context-aware Analysis") NOT ("Basic Parsing" OR "Linguistics-only") | 2019 -2025 | **2** |
| ("Word Embeddings" AND ("Word2Vec" OR "GloVe" OR "FastText"))  AND ("Transformer Models" OR "Contextual Representations")  AND ("Impact on Sentiment Analysis")  NOT ("TF-IDF" OR "Bag of Words") | 2019 -2025 | **10** |
| ("TF-IDF" OR "Term Frequency-Inverse Document Frequency")  AND ("Neural Networks" OR "Deep Learning")  AND ("Hybrid Approaches" OR "Sparse Feature Representations")  AND ("Cross-domain Adaptation" OR "Multimodal Sentiment Analysis")  NOT ("Naïve Bayes" OR "SVM" OR "Bag of Words") | 2019 -2025 | **93** |
| ("Contrastive Learning" OR "Optimization Strategies")  AND ("Sentiment Analysis" OR "Fine-tuning")  AND ("Few-shot Training on Noisy Data")  AND ("Multimodal Sentiment for Medical Documents")  NOT ("TF-IDF" OR "Lexicon-based" OR "Rule-based" OR "Review Papers") | 2019 -2025 | **0** |
| **Datasets & Resources** |  |  |
| ("IMDB Sentiment Dataset" OR "Twitter Sentiment Analysis" OR "Amazon Reviews Sentiment Dataset") AND ("Benchmark Studies" OR "Real-world Performance") NOT ("Synthetic Dataset" OR "Toy Dataset") | 2019 -2025 | **2** |
| **Evaluation Metrics** |  |  |
| ("Accuracy" OR "Precision" OR "Recall" OR "F1-score")  AND ("Deep Learning" OR "Transformer Models")  AND ("Error Propagation Analysis" OR "Robustness Benchmarking")  AND ("Adversarial Attacks" OR "Interpretability")  NOT ("Traditional ML" OR "Lexicon-based" OR "Bag of Words" OR "Simple Classifiers") | 2019 -2025 | 2 |
| ("ROC-AUC Curve" OR "Confusion Matrix")  AND ("Neural Networks" OR "Sentiment Analysis")  AND ("Robustness Testing" OR "Bias Mitigation Strategies")  AND ("Ethical AI" OR "Fairness in Sentiment Classification")  NOT ("Naïve Bayes" OR "SVM" OR "General Review") | 2019 -2025 | **14** |
| **Challenges & Open Research Areas** |  |  |
| ("Sarcasm Detection" OR "Contextual Sentiment Understanding")  AND ("Transformer-based" OR "BERT" OR "Zero-shot Learning")  AND ("Emerging Challenges" OR "Performance Bottlenecks")  NOT ("Rule-based" OR "Lexicon-based") | 2019 -2025 | 9 |
| ("Multilingual Sentiment Analysis" OR "Code-Mixed Sentiment Analysis") AND ("Low-resource Languages" OR "Cross-lingual Transfer") NOT ("English-only" OR "Simple Classification") | 2019 -2025 | 25 |
| ("Fake Review Detection" OR "Domain Adaptation")  AND ("Real-world Implementation" OR "Transformer Models")  AND ("Cross-domain Generalization" OR "Adversarial Learning")  NOT ("Basic Classification" OR "Synthetic Dataset") | 2019 -2025 | **44** |

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| **KEYWORDS SEARCH** | **Year Range** | **NUMBER OF HITS** |
| **General Sentiment Analysis Terms** |  |  |
| **("Sentiment Analysis" OR "Opinion Mining")** AND **("Peer-reviewed Journal" OR "ACL" OR "EMNLP" OR "NAACL" OR "ICML" OR "NeurIPS")** AND **("Machine Learning" OR "Deep Learning" OR "Lexicon-based")** NOT **("Book Chapter" OR "Survey Paper" OR "Review Article")** **(2019-2025)** | 2019 -2025 | **278** |
| **Lexicon-Based Sentiment Analysis** |  |  |
| **("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis")** AND **("WordNet" OR "SentiWordNet" OR "VADER" OR "AFINN")** AND **("Supervised Learning" OR "Hybrid Approach")** AND **("ACL" OR "EMNLP" OR "NAACL" OR "Peer-reviewed Journal")** NOT **("TF-IDF" OR "Bag of Words" OR "Review Paper")** **(2019-2025)** | 2019 -2025 | **35** |
| Machine Learning & Sentiment Analysis |  |  |
| **("Machine Learning" AND "Sentiment Analysis")** AND **("Neural Networks" OR "Transformer Models" OR "Contrastive Learning")** AND **("Benchmarking on Public Datasets" OR "Real-world Applications")** AND **("ACL" OR "EMNLP" OR "NAACL" OR "ICML" OR "NeurIPS")** NOT **("Traditional ML" OR "SVM" OR "Naïve Bayes" OR "Decision Trees")** **(2019-2025)** | 2019 -2025 | **298** |
| Deep Learning Approaches for Sentiment Analysis |  |  |
| **("Deep Learning" AND "Sentiment Analysis")** AND **("BERT" OR "GPT" OR "LSTM" OR "XLNet")** AND **("Fine-tuning" OR "Few-shot Learning" OR "Zero-shot Learning")** AND **("ICML" OR "NeurIPS" OR "Peer-reviewed Journal")** NOT **("SVM" OR "Lexicon-based" OR "Bag of Words")** **(2019-2025)** | 2019 -2025 | **332** |
| Transformer-Based Sentiment Analysis |  |  |
| **("Transformer-based Sentiment Analysis" OR "BERT" OR "GPT" OR "XLNet")** AND **("Self-supervised Learning" OR "Domain Adaptation")** AND **("Recent Developments" OR "Comparative Analysis")** AND **("ACL" OR "NAACL" OR "EMNLP" OR "Peer-reviewed Journal")** NOT **("Traditional ML" OR "TF-IDF" OR "Lexicon-based")** **(2019-2025)** | 2019 -2025 | 139 |
| Sentiment Analysis in Low-Resource Languages |  |  |
| **("Sentiment Analysis" AND "Low-resource Languages")** AND **("Multilingual NLP" OR "Cross-lingual Transfer Learning")** AND **("Data Augmentation" OR "Few-shot Learning")** AND **("ACL" OR "EMNLP" OR "NAACL" OR "Peer-reviewed Journal")** NOT **("English-only Models" OR "Lexicon-based")** **(2019-2025)** | 2019 -2025 | 8 |
| **Evaluation Metrics for Sentiment Analysis** |  |  |
| **("Accuracy" OR "Precision" OR "Recall" OR "F1-score") AND ("Deep Learning" OR "Transformer Models") AND ("Performance Benchmarking" OR "Optimization Strategies" OR "Error Analysis") AND ("ICML" OR "NeurIPS" OR "Peer-reviewed Journal") NOT ("Traditional ML" OR "Bag of Words") (2019-2025)** | 2019 -2025 | 75 |
| **Robustness & Challenges in Sentiment Analysis** |  |  |
| **("Adversarial Attacks" OR "Bias in Sentiment Analysis") AND ("Robustness Testing" OR "Fairness in NLP Models") AND ("ACL" OR "EMNLP" OR "ICML" OR "Peer-reviewed Journal") NOT ("Review Paper" OR "Survey Article") (2019-2025)** |  | 3 |

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| **KEYWORDS SEARCH** | **Year Range** | **NUMBER OF HITS** |
| **General Sentiment Analysis Terms** |  |  |
| ("Sentiment Analysis" OR "Opinion Mining")  AND ("Peer-reviewed Journal" OR "ACL" OR "EMNLP" OR "NAACL" OR "ICML" OR "NeurIPS")  AND ("Neural Networks" OR "Deep Learning" OR "Transformer Models")  AND ("Real-world Implementation" OR "Benchmarking on Public Datasets")  NOT ("Survey Paper" OR "Review Article" OR "Lexicon-based Approach")  (2019-2025) | 2019 -2025 | **24** |
| **Lexicon-Based Sentiment Analysis** |  |  |
| **("Lexicon-based Sentiment Analysis" OR "Rule-based Sentiment Analysis")** AND **("WordNet" OR "SentiWordNet" OR "VADER" OR "AFINN")** AND **("Supervised Learning" OR "Hybrid Approach")** AND **("ACL" OR "EMNLP" OR "NAACL" OR "Peer-reviewed Journal")** NOT **("TF-IDF" OR "Bag of Words" OR "Review Paper")** **(2019-2025)** | 2019 -2025 | **35** |
| Machine Learning & Sentiment Analysis |  |  |
| **("Sentiment Analysis with Transformer Models")**  **AND ("BERT-based Sentiment Classification" OR "GPT-based Sentiment Analysis" OR "T5-based Fine-tuning")**  **AND ("Contrastive Learning for Sentiment" OR "Self-supervised Sentiment Classification")**  **AND ("Evaluation using F1-score" OR "Error Analysis in Domain-specific Sentiment Models")**  **AND ("ACL" OR "EMNLP" OR "ICML" OR "NeurIPS")**  **NOT ("Traditional ML" OR "SVM" OR "Naïve Bayes" OR "Decision Trees" OR "Lexicon-based Sentiment")**  **(2020-2025)** | 2019 -2025 | **0** |
| Deep Learning Approaches for Sentiment Analysis |  |  |
| **("Sentiment Analysis" AND "Deep Learning")**  **AND ("BERT" OR "GPT-4" OR "XLNet" OR "T5")**  **AND ("Fine-tuning on Domain-Specific Data" OR "Zero-shot Learning for Sentiment")**  **AND ("ICML" OR "NeurIPS" OR "Peer-reviewed Journal")**  **NOT ("LSTM" OR "CNN" OR "Lexicon-based" OR "Rule-based")**  **(2019-2025)** | 2019 -2025 | **9** |
| Transformer-Based Sentiment Analysis |  |  |
| **("Transformer-based Sentiment Analysis" OR "BERT" OR "GPT" OR "XLNet")** AND **("Self-supervised Learning" OR "Domain Adaptation")** AND **("Recent Developments" OR "Comparative Analysis")** AND **("ACL" OR "NAACL" OR "EMNLP" OR "Peer-reviewed Journal")** NOT **("Traditional ML" OR "TF-IDF" OR "Lexicon-based")** **(2019-2025)** | 2019 -2025 | 139 |
| Sentiment Analysis in Low-Resource Languages |  |  |
| **("Sentiment Analysis" AND "Low-resource Languages")** AND **("Multilingual NLP" OR "Cross-lingual Transfer Learning")** AND **("Data Augmentation" OR "Few-shot Learning")** AND **("ACL" OR "EMNLP" OR "NAACL" OR "Peer-reviewed Journal")** NOT **("English-only Models" OR "Lexicon-based")** **(2019-2025)** | 2019 -2025 | 8 |
| **Evaluation Metrics for Sentiment Analysis** |  |  |
| **("Accuracy" OR "Precision" OR "Recall" OR "F1-score") AND ("Deep Learning" OR "Transformer Models") AND ("Performance Benchmarking" OR "Optimization Strategies" OR "Error Analysis") AND ("ICML" OR "NeurIPS" OR "Peer-reviewed Journal") NOT ("Traditional ML" OR "Bag of Words") (2019-2025)** | 2019 -2025 | 75 |
| **Robustness & Challenges in Sentiment Analysis** |  |  |
| **("Adversarial Attacks" OR "Bias in Sentiment Analysis") AND ("Robustness Testing" OR "Fairness in NLP Models") AND ("ACL" OR "EMNLP" OR "ICML" OR "Peer-reviewed Journal") NOT ("Review Paper" OR "Survey Article") (2019-2025)** |  | 3 |

**LITERATURE SEARCH**

**If educational aspect:**

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| --- | --- | --- | --- | --- | --- | --- |
| **TITLE AND AUTHORS** | **PUBLICATION VENUE AND YEAR** | **RESEARCH PROBLEM AND OBJECTIVES** | **METHODOLOGY USED** | **KEY FINDINGS AND CONTRIBUTIONS** | **LIMITATIONS AND FUTURE DIRECTIONS** | **PERSONAL REFLECTIONS AND CRITIQUE** |
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| **TITLE AND AUTHORS** |  | **HIGHLIGHTS IN THE INTRODUCTION** | **METHODS** | **PARTICIPANT** | **RESULTS** | **RECOMMENDATION/ CONCLUSION** |
| ***Inverse Kinematics for 6-DOF Serial Manipulators With Offset or Reduced Wrists via a Hierarchical Iterative Algorithm* Authors**: Jing Xu, Kechen Song, Yu He, Zhipeng Dong, Yunhui Yan |  | * **Challenge of Inverse Kinematics (IK): Solving IK for 6-DOF manipulators with offset or reduced wrists is difficult due to complex, nonlinear, and coupled equations.** * **IK Importance: Critical for structural design, motion planning, and dynamic analysis of manipulators.** * **Limitations of Existing Methods:** * **Analytical methods are often inapplicable for complex manipulator configurations.** * **Numerical methods struggle with accuracy, computational efficiency, and handling multiple solutions.** * **Proposed Solution: The Hierarchical Iterative Inverse Kinematic Algorithm (HIIKA) consists of:** * **Two-Level Iteration:**   + **First level provides accurate initial estimates through an extended heuristic method.**   + **Second level calculates joint angles analytically, improving convergence and computational efficiency.** * **Advantages of HIIKA: Offers improved accuracy, computational efficiency, and the ability to calculate multiple solutions without dealing with Jacobian singularities.** | **Algorithm Framework (Section II)**   * **HIIKA Structure:**   + **Two-Level Iterations:**     - **First-Level: Obtains initial estimations for joint 1 angle.**     - **Second-Level: Solves for other joint angles using the initial estimations.** * **Verification: Checks IK solutions against allowed EE position (ε) and orientation (γ) errors.** * **Error Correction: Adjusts joint 1 angle if solutions are incorrect, repeating until errors meet criteria.** * **Solution Selection: Applies joint constraints for optimal IK solutions.**   **Forward Kinematics (Section III)**   * **D-H Convention: Defines manipulator structure and coordinates.**   **Inverse Kinematics (Section IV)**   * **Extended Heuristic Method: Iteratively calculates joint angles based on initial estimations.** * **Configuration Estimation: Adjusts joint angles within allowed ranges for proper EE positioning.** * **Solving All DOF: Computes angles and searches for corrections as needed.** * **Singularity Handling: Analyzes configurations to avoid computational issues.**   **Simulations and Discussion (Section V)**   * **Performance Evaluation: Assesses HIIKA's convergence, accuracy, and efficiency.** * **Motion Planning: Compares trajectory simulations using HIIKA and NIKA for effectiveness.** | **Manipulator: A 6-DOF serial manipulator with a 2-DOF reduced wrist.** | * **Convergence and Accuracy: HIIKA improved convergence and accuracy for solving IK.** * **Computational Efficiency: Achieved real-time solutions with low allowed errors.** * **Multiple Solutions: Effectively found multiple IK solutions near accurate initial estimations.** * **Motion Planning: Successfully completed a rectangular path with 100 points in 1.7687 seconds; average computational time was 17.7 ms per point.** * **Validation: Confirmed HIIKA's effectiveness for manipulators with offset or reduced wrists.** | * **HIIKA Development: The paper introduces the Hierarchical Iterative Inverse Kinematic Algorithm (HIIKA) specifically for solving the IK problem in 6-DOF manipulators with offset or reduced wrists.** * **Challenges Addressed: It addresses limitations of traditional numerical methods, including:** * **High dimensional search space** * **Inaccurate initial estimations** * **Singularities** * **Multiple solutions and additional constraints** * **Advantages of HIIKA:** * **Enhances convergence, accuracy, and computational efficiency.** * **Capable of producing continuous and smooth motion trajectories for each joint.** * **Performance Validation: Experimental results confirm HIIKA's effectiveness and superiority in handling the complexities of IK solutions.** |
| **TITLE AND AUTHORS** |  | **HIGHLIGHTS IN THE INTRODUCTION** | **METHODS** | **PARTICIPANT** | **RESULTS** | **RECOMMENDATION/ CONCLUSION** |
| **Bridging the Skill Gap in Robotics: Global and National Environment**   * **Authors: Natalia Shmatko and Galina Volkova** |  | * **The demand for robotics professionals is increasing globally due to rapid advancements in robotics and artificial intelligence.** * **Key skills required in the field include a combination of hard skills (programming and specialized software knowledge) and soft skills (communication and self-motivation).** * **Interdisciplinary skills, such as knowledge of AI and new materials, are becoming essential.** * **Policymakers face challenges in enhancing education and skill development systems to meet this growing demand.** * **Collaboration between universities, research institutions, and industries is crucial for technological advancements.** * **The study compares skill demands for robotics professionals in the U.S. and Russia, focusing on articulated versus expected skills in job postings.**   **Research Questions**   1. **What are the most in-demand skills for robotics professionals?** 2. **How do hard, digital, and soft skills interconnect?** 3. **What are the specific skill requirements in Russia compared to the U.S.?** 4. **What skills are explicitly stated in job postings versus expected by employers?** | * **Study Focus: Demand for qualified engineering and research personnel in robotics (2016-2018).** * **Skill Classification:** * **Hard Skills: Technical knowledge specific to robotics.** * **Soft Skills: Personal and social traits impacting work productivity.** * **Data Sources: Analyzed job vacancies from Indeed.com and hh.ru for skill requirements.** * **Data Collection:** * **Used Python tools to gather 960 English-language and 360 Russian vacancies.** * **Skill Thesaurus: Developed a thesaurus categorizing skills by area, education, hard skills, software, and soft skills.** * **Comparative Analysis: Focused on U.S. vacancies as a benchmark for robotics standards.** * **Limitations: Addressed gaps in online postings, particularly for research roles.** * **Expert Interviews: Conducted 29 structured interviews across industry, research, and higher education sectors to supplement vacancy analysis.** * **Content Analysis: Identified trends and anonymized expert responses with illustrative quotes.** | * **Expert Interviewees:** * **Total: 29 experts from various sectors related to robotics.** * **Sectors Represented:**   + **Industry: CEOs of production companies specializing in robotics.**   + **Research: Leading researchers from research institutes.**   + **Higher Education: Representatives from universities, including heads of faculties and departments, as well as leaders of educational and engineering laboratories.** * **Qualifications: All participants hold high managerial positions responsible for corporate strategies and the training of future robotics professionals.** * **Interview Duration: Approximately 45 to 60 minutes per interview.** * **Confidentiality: Expert names and organizations were anonymized in the analysis, with responses coded (e.g., Expert 1, etc.) and sector information provided.** | **Required Skills in Robotics**   * **Technical Skills:**   + **Programming:**     - **C/C++ is the most sought-after language (11.4% U.S., 23.7% Russia).**     - **Python is also important (7.6% U.S., 8.5% Russia).**   + **Software Proficiency: AutoCAD, MATLAB, SolidWorks.**   + **Practical Skills: Assembly, welding, and soldering.** * **Soft Skills:**   + **Emphasis on teamwork, communication, and adaptability.**   + **Importance of problem-solving, creativity, and stress management.**   + **English proficiency is essential for Russian professionals.**   **Requirements in Russia**   * **Key R&D Areas:**   1. **Informatics**   2. **Mechanics**   3. **Automation**   4. **Electronics**   5. **AI technology** * **Interdisciplinary Skills:**   1. **Growing need for knowledge in AI, new materials, and medical robotics.** | * **Skill Shortage: A significant global shortage of skilled robotics professionals hampers development.** * **Training Systems: Staff training must balance current employer needs with future skill requirements.** * **Diverse Skills: Robotics professionals need a broad range of hard (programming, practical skills) and soft skills (teamwork, communication).** * **English Proficiency: Practical English skills are essential for global collaboration in robotics.** * **Employer Preferences: Employers value multidisciplinary knowledge and motivation over narrow specialization.** * **Focus on Internal Training: Upgrading existing staff and hiring motivated graduates is preferred over importing foreign specialists.** * **Policy Development: There is a need for improved government policies to address skills shortages.** * **Future Research: Further studies should explore robotics skills in other countries and sectors beyond industrial applications.** |
| **TITLE AND AUTHORS** |  | **HIGHLIGHTS IN THE INTRODUCTION** | **METHODS** | **PARTICIPANT** | **RESULTS** | **RECOMMENDATION/ CONCLUSION** |
| **A Novel Real-Time MATLAB/Simulink/LEGO EV3 Platform for Academic Use in Robotics and Computer Science**  **Authors:**   * **Nicolas Montes** * **Nuria Rosillo** * **Marta C. Mora** * **Lucia Hilario** |  | * **Role of Low-Cost Systems: Increasing importance of low-cost hardware/software systems in education across all levels.** * **Popular Platforms: Notable platforms include Arduino, Raspberry Pi, and LEGO Mindstorms for robotics education.** * **LEGO Mindstorms: Has significantly impacted college engineering education due to its customizable and programmable robot kits.** * **Key Features of LEGO EV3:** * **Faster clock speed (300 MHz) compared to previous versions (NXT).** * **Introduction of Wi-Fi connectivity, enabling communication with external environments.** * **Educational Applications:** * **LEGO robots are used in various subjects, combined with different programming languages and platforms.** * **MATLAB and Simulink are frequently used with LEGO robots for complex and real-time applications.** * **Objective of the Research: Evaluate the MATLAB/Simulink/LEGO EV3 platform's effectiveness as a generic engineering education tool through Project Based Learning (PBL) methodology.** * **Research Questions: Three key research questions are posed to assess the platform's capabilities in different educational contexts.** | * **Project-Based Learning (PBL) used across different educational levels.** * **Undergraduates implemented existing navigation algorithms.** * **Graduate students developed complex algorithms.** * **PhD students tested new research algorithms.** * **Data collected via reports, field notes, mini-interviews, and external evaluations.** | **1) Undergraduate Students:**   * **Two students from the computer science program.** * **Developed their final degree projects using the educational framework.**   **2) Graduate Student:**   * **Specialized in robotics.** * **Completed an internship project involving advanced navigation algorithms.**   **3) PhD Students:**   * **Engaged in research testing.** * **Developed and tested new path planning algorithms within the platform.** | **1) Data Overview:**   * **Tables:**   + **Table 3: Mini-interview question responses.**   + **Table 4: External evaluation scores for projects.**   **2) RQ1:**   * **Students show improved understanding of mathematical models, especially those with prior robotics knowledge.**   **3) RQ2:**   * **All students successfully built and controlled robots by mid-project; high external evaluation scores (100%) indicate strong procedural competence.**   **4) RQ3:**   * **Increased ease in programming reported; all students achieved perfect scores in robot-platform interaction.**   **5) Project Types:**   * **Type A: Undergraduates successfully implemented MATLAB path planning without prior knowledge.** * **Type B: Intern with foundational knowledge navigated robots using complex algorithms.** * **Type C: PhD students applied complex models, enhancing skills.**   **6) Platform Benefits:**   * **MATLAB/Simulink/LEGO EV3 enables diverse, low-cost educational applications.**   **7) Limitations:**   * **Not all MATLAB functions compile on LEGO; distinct skills needed for different programming languages.** | **1) Platform Validation:**   * **Educational platform combining MATLAB-Simulink with LEGO EV3 enables real-time interactive projects and research activities.**   **2) Knowledge Integration:**   * **Supports the integration of abstract, physical, procedural, and logico-mathematical knowledge.**   **3) Advantages:**   * **Facilitates real-time applications that enhance student and lecturer engagement in learning.**   **4) Limitations:**   * **Not all MATLAB functions are compatible; MATLAB functions may require recoding for variable definition.**   **5) Future Work:**   * **Plan to apply the platform across different subjects to validate results.** * **Explore extension to other low-cost hardware (e.g., Arduino, Raspberry Pi) for comparative applicability studies.** |