Carel **van Niekerk**

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Summary

Research Scientist / Engineer specialising in **Reinforcement Learning (RL) Post-training** and **Large Language Models Alignment**. Expert in developing methods for **model trustworthiness**, **uncertainty quantification**, and **hallucination reduction**. Proven ability to bridge **rigorous** mathematical theory and production-level **engineering** by designing **scalable**, **reliable** and **modular** training frameworks. Extensive publication record at **NeurIPS**, **ACL**, and **EMNLP**, with a focus on delivering **creative**, high-impact solutions to complex research challenges.

Skills

Research	Reinforcement Learning (Reinforcement Learning from Human/Intrinsic Feedback), Uncertainty Quantification, Self-supervised Learning, LLM Evaluation & Benchmarking, Human-in-the-loop, Model Debugging, Distribution Theory.
Deep Learning	PyTorch, Hugging Face Ecosystem (Transformers, TRL, Accelerate, Datasets).
Agentic Systems	LangGraph, DeepEval.
Programming	Python (Advanced), C++, Rust, MyPy/Ty (Type Checking in Python).
Infrastructure	Distributed Training (DeepSpeed, Accelerate), HPC Scheduling (SLURM), Cloud Orchestration (SkyPilot), Hydra (Configuration Management).
Engineering	Software Engineering and Design Patterns, Testing and Formatting (PyTest, Ruff), Debugging (pdb/VSCode), API Development (FastAPI, Pydantic).
Core	Technical Leadership & Mentorship, Technical Writing, Collaboration, Mathematical Statistics, Linear Algebra & Calculus.
Languages	English (Native), Afrikaans (Native), German (Fluent).

Experience

Postdoctoral Researcher

March 2024 – Present

Heinrich Heine University — *Düsseldorf, Germany*

- **Agentic Multi-Agent Reinforcement Learning**: Led the development of a MARL framework for telephonic dialogue systems, enabling coordinated decision-making between router and expert agents with explicit credit assignment. This approach improved routing accuracy by **over 15 percentage points** in a production-level dialogue product.
- **HydraXcel**: Sole developer and maintainer of an open-source, configuration-driven deep learning experiment launcher. Integrated Facebook Hydra, Hugging Face Accelerate, and the UV workflow to support **scalable multi-GPU and distributed training**. The framework enables seamless, scalable **multi-GPU and distributed training** for the research team.
- **HPC & Cloud Training Infrastructure**: Designed and implemented Hydra launcher plugins enabling transparent execution of experiments on **SLURM**-managed HPC clusters and via **SkyPilot** on cloud platforms. This infrastructure enabled high-throughput experimentation and rapid switching between compute backends without code changes.
- **Academic Leadership**: Supervised multiple Master's theses focused on MARL and task-oriented dialogue. Designed and instructed the "Implementing Transformers" course, guiding students through building the *Attention Is All You Need* architecture from first principles in **PyTorch**, with emphasis on attention mechanics, training dynamics, and debugging. Achieved a 95% course pass rate.

PhD Candidate

Jul 2019 – Mar 2024

Heinrich Heine University — *Düsseldorf, Germany*

- **Uncertainty-Aware Decision Making**: Developed computationally efficient methods for uncertainty quantification in intent classification in collaboration with Yandex Research. Integrated uncertainty features into reinforcement learning policies, improving real-user interaction success by **5 percentage points**. Designed an **Active Learning** strategy that achieved full-dataset performance using only **16% of expert annotations**.
- **ConvLab-3 Dialogue Systems Toolkit**: Core developer of a large-scale dialogue system toolkit in collaboration with Tsinghua University and Microsoft Research. Architected a unified data format enabling seamless integration of heterogeneous datasets and models, significantly reducing engineering overhead for generalisation and reinforcement learning research. The toolkit has been adopted in **30+ research papers** spanning RL- and LLM-based dialogue agents.
- **Young Researchers Roundtable on Spoken Dialogue Systems (YRRSDS)**: Co-organised the 2022 edition collocated with **SIGDIAL** in Edinburgh. Managed the digital infrastructure and branding for the workshop and contributed to **sponsorship acquisition**.

Artificial Intelligence Applications Consultant

Jun 2018 – May 2019

NGA Risksecure — *Pretoria, South Africa*

- **Named Entity Sentiment Analysis**: Co-developed a sentiment scoring system for news-based entities, delivering reliable quantitative metrics to banking clients at **under 70% of the cost** of manual analysis.
- **Multimodal Computer Vision Systems**: Developed a proof-of-concept application combining visual and sensor data to monitor greenhouse plant health for a CBD producer in Southern Africa.

Selected Publications

Post-Training Large Language Models via Reinforcement Learning from Self-Feedback *Jul 2025*

Carel van Niekerk, Renato Vukovic, Benjamin Matthias Ruppik, et al. *Under revision at EACL*

- Developed Reinforcement Learning from Self-Feedback (RLSF), a novel **post-training technique** utilising **intrinsic model confidence** to reduce reliance on external human preference data.
- Demonstrated that RL based on intrinsic feedback is a **data-efficient alternative for the LLM post-training pipeline**, reaching beam-search performance with single-trace decoding.

Less is More: Local Intrinsic Dimensions of Contextual Language Models *Oct 2025*

Benjamin Matthias Ruppik, Julius von Rohrscheidt, Carel van Niekerk, Michael Heck, et al. *NeurIPS 2025*

- Identified that Local Intrinsic Dimensions (LID) provide **critical insights into model training dynamics** and generalisation ability.
- Proved that mean LID serves as a predictive metric for training capability exhaustion, **overfitting** in classification tasks, and the emergence of **"grokking"** in arithmetic tasks.

Education

PhD in Computer Science *Jul 2019 – Mar 2024*

Heinrich Heine University *Düsseldorf, Germany*

Focus: *Uncertainty Estimation, Management, and Utilisation in Human-Computer Dialogue*

MSc in Mathematical Statistics *Jan 2017 – Nov 2018*

University of Pretoria *Pretoria, South Africa*

Relevant Modules: *Statistical Learning, Data Analytics and Visualization, Mini-Dissertation*

BSc (Hons) in Mathematical Statistics *Jan 2016 – Nov 2016*

University of Pretoria *Pretoria, South Africa*

Relevant Modules: *Linear Models, Process Control, Research Report*

BSc in Actuarial and Financial Mathematics *Jan 2013 – Nov 2015*

University of Pretoria *Pretoria, South Africa*

Relevant Modules: *Mathematical Statistics, Imperative Programming, Linear Algebra, Calculus*

Research Themes

Alignment-Oriented Post-Training	Reinforcement learning methods for aligning large language models using intrinsic and self-supervised reward signals, reducing reliance on external human preference data.
Agentic and Tool-Augmented Systems	Reinforcement learning and multi-agent coordination for long-horizon decision making in agentic dialogue and tool-using systems.
Uncertainty-Aware Reasoning	Bayesian and distributional methods for uncertainty estimation, calibration, and robustness, with applications to trustworthy and controllable AI systems.
Scalable Research Infrastructure	Design of reproducible, configurable, and distributed training systems enabling rapid experimentation across HPC and cloud environments.