Document Control Sheet

1. ISBN or ISSN	2. Type of Report Final Report
3a. Report Title VICKI; Artificial intelligence for prediction of inhomogeneities and cluster dynamic	
3b. Title of Publication	

4a. Author(s) of the Report (Family Name, First Name(s)) Prof. Dr.-Ing. Benjamin Noack Dr. Dmitry Puzyrev	5.End of Project 31.08.2025
	6. Publication Date
4b. Author(s) of the Publication (Family Name, First Name(s))	7. Form of Publication Final Report

8. Performing Organization(s) (Name, Address) Research Group “Autonomous Multisensor Systems” Faculty of Informatics Otto-von-Guericke-University Magdeburg Universitätsplatz 2 39106 Magdeburg Germany	9. Originator’s Report No.
	10. Reference No. 50WM2252
	11a. No. of Pages Report 18
	11b. No. of Pages Publication
13. Sponsoring Agency (Name, Address) Deutsche Raumfahrtagentur im Deutschen Zentrum für Luft- und Raumfahrt e.V. Königswinterer Str. 522-524 53227 Bonn	12. No. of References 28
	14. No. of Tables
	15. No. of Figures 7

16. Supplementary Notes

17. Presented at (Title, Place, Date)

18. Abstract

The goal of project VICKI was the use of Artificial intelligence/Machine learning (AI/ML) methods for prediction of clustering in granular particle ensembles with low particle density (Granular Gases). The project was concerned with the effect when external excitation of the ensemble with a certain minimal global packing fraction leads to creation of high-density regions where the system behaves more like a liquid. This clustering can be localized and dynamic.

Experiments with such ensembles require high-precision microgravity, and to observe the onset of clustering, long microgravity times are often needed as well. This makes the experimental study of such systems extremely hard to achieve. The majority of theoretical studies have been conducted with numerical simulations based on DEM methods, which have particularly high computational costs.

Project VICKI was focused on the possibility to predict the dynamical clustering results for different systems based on the system parameters without the need of costly DEM simulations. Instead, the behavior of such complex and non-linear systems can be predicted by ML models trained on the simulated data. Comparison with experimental results also benefits the robustness of the predictions and helps to avoid obvious mistakes which are possible by application of AI/ML based methods.

In VICKI project, multiple simulations of systems with different packing fractions and external excitation parameters were performed, and based on these data different ML methods were tested. The prediction results for spherical and rod-shaped particles were achieved. The workflow developed in project VICKI can be extended to other system geometries and particle shapes. Simulations for particles of complex shapes with higher clustering affinity were performed as well.

In addition to the study of granular gases, the experimental data related to jamming transition in the silo outflow of the mixed soft and hard particles was collected and analyzed with the help of ML methods. The simulation code was developed for augmentation of the data and better understanding of such systems. Here, results on the possibility of predicting the upcoming clogs based on the current state and dynamics of the system have been achieved.

19.Keywords

Artificial intelligence, machine learning, microgravity, granular gas, dynamical clustering, discrete element method

20. Publisher	21. Price