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## Learning Vector Quantization with Applications in Neuroimaging and Biomedicine

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# **Learning Vector Quantization with Applications in Neuroimaging and Biomedicine**

**Rick van Veen**

**Cover & layout**

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university of  
 groningen

# Learning Vector Quantization with Applications in Neuroimaging and Biomedicine

**PhD thesis**

to obtain the degree of PhD at the  
 University of Groningen  
 on the authority of the  
 Rector Magnificus Prof. Dr. C. Wijmenga  
 and in accordance with  
 the decision by the College of Deans.

This thesis will be defended in public on

Monday 2 May 2022 at 12:45 hours

by

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# Abbreviations

## Machine Learning

AUC	Area under the receiver operating characteristic curve
GLVQ	Generalized learning vector quantization
GMLVQ	Generalized matrix learning vector quantization
LGMLVQ	Localized generalized matrix learning vector quantization
LVQ	Learning vector quantization
NPC	Nearest prototype classification
PCA	Principal component analysis
ROC	Receiver operating characteristic
sklvq	scikit-learning vector quantization
SVD	Singular value decomposition
SVM	Support vector machine
VAF	Variance accounted for

## Neuroscience

AD	Alzheimer's disease
ADRP	Alzheimer's disease-related pattern
CBD	Corticobasal degeneration
CT	Computerized tomography
CUN	Clinica Universidad de Navarra
DLB	Dementia with Lewy bodies

## ABBREVIATIONS

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FDG	[ <sup>18</sup> F] fluorodeoxyglucose
FTD	Frontotemporal dementia
GIS	Group invariant sub-profiles
GLIMPS	Glucose imaging in Parkinsonian syndromes
GMP	Group mean profile
HC	Healthy control
iRBD	Idiopathic rapid eye movement sleep behavior disorder
MCI	Mild cognitive impairment
MNI	Montreal Neurological Institute
MRI	Magnetic resonance imaging
MSA	Multiple system atrophy
PD	Parkinson's disease
PDD	Parkinson's disease dementia
PDRP	Parkinson's disease-related pattern
PET	Positron emission tomography
PSP	Progressive supranuclear palsy
RBD	Rapid eye movement sleep behavior disorder
rCMR <sub>glu</sub>	Regional cerebral metabolic rates of glucose
SRP	Subject residual profile
SSM	Scaled subprofile model
UGOSM	University of Genoa and IRCCS AOU San Martino-IST
UMCG	University Medical Center Groningen

### **Biomedical**

ACA	Adrenocortical adenoma
ACC	Adrenocortical carcinoma
ENSAT	European network for study of adrenal tumors
GC-MS	Gas chromatography–mass spectrometry
LC-MS	Liquid chromatography–mass spectrometry

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# Publications

The following list contains publications both related and not related to this thesis. If a publication is not related to the thesis, this is explicitly mentioned.

## Conference Contributions

S. Ghosh *et al.*, “Comparison of strategies to learn from imbalanced classes for computer aided diagnosis of inborn steroidogenic disorders,” in *25th European Symposium on Artificial Neural Networks, Computational Intelligence and Machine Learning, ESANN 2017*, M. Verleysen, Ed., Ciaco - i6doc.com, Apr. 2017, pp. 199–205, ISBN: 978-2-87587-038-4 (unrelated to this thesis)

S. Fallmann, R. van Veen, L. Chen, D. Walker, F. Chen, and C. Pan, “Wearable accelerometer based extended sleep position recognition,” in *2017 IEEE 19th International Conference on e-Health Networking, Applications and Services (Healthcom)*, IEEE, Oct. 2017. DOI: 10.1109/healthcom.2017.8210806 (unrelated to this thesis)

R. van Veen *et al.*, “Machine Learning Based Analysis of FDG-PET Image Data for the Diagnosis of Neurodegenerative Diseases,” in *Applications of Intelligent Systems*, N. Petkov, N. Strisciuglio, and C. Travieso-González, Eds., ser. *Frontiers in Artificial Intelligence and Applications*. 2018, vol. 310, pp. 280–289, ISBN: 978-1-61499-928-7. DOI: 10.3233/978-1-61499-929-4-280

## Journal Publications (Published)

R. van Veen *et al.*, “An application of generalized matrix learning vector quantization in neuroimaging,” *Computer Methods and Programs in Biomedicine*, vol. 197, p. 105708, 2020, ISSN: 0169-2607. DOI: 10.1016/j.cmpb.2020.105708

R. van Veen, M. Biehl, and J. J. G. de Vries, “Sklvq: Scikit learning vector quantization,” *Journal of Machine Learning Research*, vol. 22, no. 231, pp. 1–6, 2021. [Online]. Available: <http://jmlr.org/papers/v22/21-0029.html>

### **Journal Publications (In preparation)**

A .E. Taylor, I Bancos, Lorna C. Gilligan, R. van Veen, *et al.*, "Diagnosis of adrenocortical cancer via urinary steroid profiling using mass spectrometry. Comparison of gas chromatography mass spectrometry to ultra-high pressure liquid chromatography mass spectrometry," 2022. (In preparation)

R. van Veen, S. K. Meles, R. J. Renken, *et al.*, "FDG-PET combined with Learning Vector Quantization allows classification of neurodegenerative diseases and reveals the trajectory of idiopathic REM sleep behavior disorder," 2022. (In preparation)

R. van Veen, N. R. B. Tambolia, J. J. G. de Vries, M. Biehl, *et al.*, "Subspace corrected relevance learning with application in neuroimaging," 2022. (In preparation)