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A First Use Case for Quantum-ML in Media Science

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Quantum Humanities:
A First Use Case for Quantum-ML in Media Science

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Quantum Humanities, the vison of combining quantum computing and digital humanities, is a promising new research field that aims at supporting digital humanities by using the advantages provided by the upcoming technology of the quantum computer for addressing existing as well as completely new questions in the humanities. To foster the vision of quantum humanities we want to outline a beneficial use case from the field of media science using machine learning algorithms implemented on quantum computers to solve issues from the humanities.

1. Introduction

The establishment of digital humanities as a research field has shown that the use of computers and techniques from computer science can contribute enormously to research done in the humanities [1]. Since quantum computers are getting real, it is promising to use the advantages of this upcoming technology for addressing existing as well as completely new questions in the humanities, as outlined in the vision for quantum humanities [2]. There are multiple benefits the quantum computer provides in specific areas compared to a classical computer, like being significantly faster [3], processing a vast amount of data in a single step [4] being more precise [5], solving problem classes that were previously considered practically unsolvable [4] or solving problems that can only be solved on a quantum computer [6]. Some of these benefits can in particular contribute to problems stated in the humanities, as shown below in a use case from our digital humanities project MUSE [7,8].

2. Use Case

MUSE includes a clothes- and costume repository supporting to capture, store and analyse clothes and costumes, focusing on costumes in films. The concrete costumes occurring in films are captured in their relevant details and are analysed to identify abstract costume patterns. At the current state there are more than 25.000 costume items with all their detailed attributes like colour, material, design, condition and way of waring [9] – to only name a few – stored in the MUSE database that need to be further analysed [10]. As Figure 1 depicts, we envision to address this with a combination of different techniques from machine learning containing an offline application part performing feature extraction via principle component analysis followed by clustering to identify new costume patterns and an online classification part, where new costumes are mapped to the already identified costume patterns.

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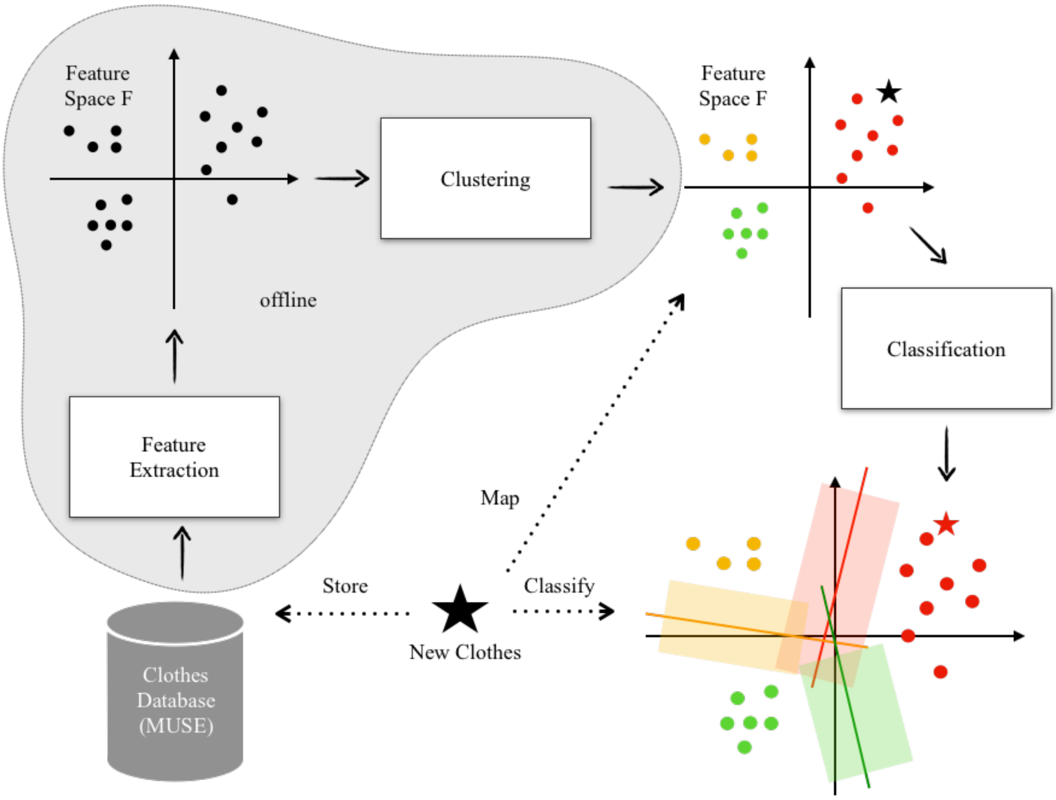

Figure 1: Analysing clothes.

This is where the use of the quantum computers can contribute: Implementations already exist for several steps outlined, that promise to be faster or more precise than on classical computers. These implementations promise to be advantageous even on nowadays quantum computers, so called NISQ machines [10]. To improve the rather time-consuming task of finding the right features building a multi-dimensional feature space, feature extraction can be supported by techniques that help to reduce the dimensions like quantum principal component analysis (PCA) [12]. PCA requires to determine eigenvalues and eigenvectors, thus, algorithms like Variational Quantum Eigensolver (VQE) [13], Phase Estimation [14] as well as HHL [15] can speed up this tremendously. Once the principal component from the costume parameters are identified, several implementations of clustering algorithms implemented on quantum computers, like Restricted Boltzmann Machines running on D-Wave [16] or Weighted Maximum Cut running on Rigetti [17], support the task to identify the clusters that hint to possible costume patterns. Whenever new costumes are added to the database, they need to be classified. To map the new clothes to the suitable cluster, classification algorithms realized on a quantum computer like Support Vector Machines implemented on the IBM quantum computer [18] promise a more precise classification due to a specific kernel function [5].

3. Conclusion and Outlook

This outlined vision for a quantum humanities use case from the media science wants to stress the potential benefits of using quantum computing technology for the humanities as well. Currently, we are in the process of implementing the stated tasks and plan to compare the achieved results with those achieved in a classical environment. With this use case we aim at providing first knowledge on how quantum applications in the digital humanities may be used in a beneficial way and to provide first, possibly reusable components for further use cases from different domains of the humanities.

About the Authors

Johanna Barzen studied media science, musicology and phonetics at the University of Cologne. Next to this she studied costume design at the ifs (international film school Cologne) and worked in several film productions in the costume department in different roles. Currently she is Postdoc and research staff member at the Institute of Architecture of Application Systems (IAAS) at the University Stuttgart performing research on Digital Humanities, Pattern Languages and Quantum Computing.

Frank Leymann is a full professor of computer science at University of Stuttgart, Germany. His research interests include service-oriented architectures and associated middleware, workflow- and business process management, cloud computing, patterns, and quantum computing. Frank is co-author of more than 450 peer-reviewed papers, about 70 patents, and several industry standards. He is elected member of the Academy of Europe.

References

[1] D. M.Berry (ed.), *Understanding Digital Humanities* Palgrave Macmillan, 2012.

[2] J. Barzen, F. Leymann, "Quantum humanities: a vision for quantum computing in digital humanities" *SICS Software-Intensive Cyber-Physical Systems*, pp 1–6, 2019, DOI: https://doi.org/10.1007/s00450-019-00419-4.

[3] T. F. Rønnow et al., "Defining and detecting quantum speedup" *Science* Vol. 345(6195) July 2014.

[4] M. A. Nielsen, I. L. Chuang, *Quantum Computation and Quantum Information*. Cambridge University Press 2010.

[5] V. Havlicek et al, "Supervised learning with quantum enhanced feature spaces" arXiv:1804.11326v2, 2018.

[6] R. Raz, A. Tal "Oracle Separation of BQP and PH" *Electronic Colloquium on Computational Complexity* Report No. 107, 2018.

[7] MUSE. https://www.iaas.uni-stuttgart.de/forschung/projekte/muse/.

[8] J. Barzen et al. "Wenn Kostüme sprechen könnten: MUSE - Ein musterbasierter Ansatz an die vestimentäre Kommunikation im Film" In: P. Bockwinkel, B. Nickel, G. Viehhauser (ed.) *Digital Humanities. Perspektiven der Praxis* Frank & Timme, 2018, pp 223-241.

[9] J. Barzen "Taxonomies of costume relevant parameters: approximating an ontology of the domain of film costumes" Technical Report No. 2013/04, University Stuttgart, 2013, https://www.iaas.uni-stuttgart.de/publications/TR-2013-04_Taxonomien-_kostuemrelevanter_Parameter.pdf".

[10] J. Barzen, "Wenn Kostüme sprechen – Musterforschung in den Digital Humanities am Beispiel vestimentärer Kommunikation im Film" Dissertation, Univerity of Cologne, 2018, https://kups.ub.uni-koeln.de/9134/.

[11] L. Preskill, "Quantum Computing in the NISQ era and beyond" Quantum 2, 79 (2018).

[12] S. Lloyd, M. Mohseni, P. Rebentrost, "Quantum principal component analysis" arXiv:1307.0401v2, 2013.

[13] A. Peruzzo et al. "A variational eigenvalue solver on a quantum processor" arXiv: 1304.3061, 2013.

[14] D. Dervovic et al. "Quantum linear systems algorithms: a primer" arXiv:1802.08227v1, 2018.

[15] A. W. Harrow, A. Hassidim, S. Lloyd "Quantum algorithm for solving linear systems of equations" arXiv: 0811.3171, 2008.

[16] M. H. Amin et al. "Quantum Boltzmann Machine" arXiv:1601.02036v1, 2016.

[17] G. E. Crooks "Performance of the Quantum Approximate Optimization Algorithm on the Maximum Cut Problem " arXiv:1811.08419v1, 2018.

[18] IBM Q Experience. https://quantum-computing.ibm.com/.

All links have been followed on September 11, 2019.