

# Murray Patterson

## Curriculum Vitae

### Education

- 2006—2012 **Doctor of Philosophy**, *Department of Computer Science, University of British Columbia, Vancouver, Canada, GPA – 4.0/4.*  
Advisors: Ján Maňuch, Cedric Chauve and Arvind Gupta  
Thesis title: “Variants of the consecutive-ones property motivated by the reconstruction of ancestral species”
- 2004—2006 **Master of Science**, *School of Computing Science, Simon Fraser University, Burnaby, British Columbia, Canada, GPA – 3.9/4.*  
Advisors: Eugenia Ternovska and Arvind Gupta  
Thesis title: “Grounding for model expansion in  $k$ -guarded formulas”
- 1999—2003 **Bachelor of Computer Science (Honours)**, *Jodrey School of Computer Science, Acadia University, Wolfville, Nova Scotia, Canada, GPA – 3.8/4 (top 5%).*  
Advisors: Raymond J. Spiteri and Jim Diamond  
Thesis title: “Implementing Runge-Kutta solvers in Java”

### Work Experience

- 2020— **Assistant Professor**, *Department of Computer Science, Georgia State University, Atlanta, Georgia, USA.*  
Teaching both undergraduate and graduate courses in computer science, as well as carrying out my research program in bioinformatics
- 2019—2020 **Visiting Assistant Professor**, *Department of Computer Science and Engineering, Fairfield University, Fairfield, Connecticut, USA.*  
Teaching both undergraduate and graduate courses in computer science, as well as carrying out my research program in bioinformatics
- 2016—2019 **Postdoctoral Researcher**, *Experimental Algorithmics Lab (AlgoLab), Informatics Department, Università degli Studi di Milano-Bicocca, Milano, Italy.*  
Advisors: Gianluca Della Vedova and Paola Bonizzoni  
Performing research on haplotype assembly, cancer phylogenetics and their application
- 2014—2016 **Postdoctoral Researcher**, *Laboratoire de Biométrie et Biologie Évolutive (LBBE), Université Claude Bernard Lyon 1, Villeurbanne, France.*  
Advisors: Daniel Kahn and Vincent Daubin  
Studying the co-evolution of (metabolic) function, and how it can be used to help the construction of phylogenetic trees

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1/9

- 2013—2014 **ERCIM Postdoctoral Research Fellow**, *Life Sciences Group, Centrum Wiskunde Informatica (CWI)*, Amsterdam, The Netherlands.  
 Advisors: Alexander Schönhuth and Gunnar W. Klau  
 Improving the state-of-the-art haplotype assembly methods for next-generation genome sequencing data  
 Research funded by ERCIM Marie Curie ABCDE Postdoctoral Fellowship
- 2012—2013 **ERCIM Postdoctoral Research Fellow**, *INRIA Rhône-Alpes and the Laboratoire de Biométrie et Biologie Évolutive, Université Claude Bernard Lyon 1*, Villeurbanne, France.  
 Advisor: Eric Tannier  
 Performing a study of the co-evolution of genes, and how it can be used to help the construction of phylogenetic trees  
 Research funded by ERCIM Marie Curie ABCDE Postdoctoral Fellowship

### Contracts

- 2022 **Research Agreement**, *AI Learning Alliance, Facebook (Meta), Inc.*, Amount: \$50,000 USD (2 years).  
 PI: Anu Bourgeois  
 To support work related to providing education at the frontier of R&D and to increase representation of historically marginalized researchers and engineers in machine learning to prepare learners for jobs in the artificial intelligence field
- 2021 **Collaboration Agreement**, *Hanyang University ERICA, Industry-University Cooperation Foundation*, Amount: \$25,000 USD (1 year).  
 PI: Zhipeng Cai  
 For the development of online modules in computer science and entrepreneurship as part of a global education program
- 2018 **Project Collaboration**, *Experimental Algorithmics Lab, Informatics Department, Università degli Studi di Milano-Bicocca*, Milano, Italy, Amount: 5,000 € (2 months).  
 Advisor: Raffaella Rizzi  
 The development of efficient algorithms for comparing evolutionary histories of cancerous tumours as inferred by the latest methods
- 2017 **Project Collaboration**, *Experimental Algorithmics Lab, Informatics Department, Università degli Studi di Milano-Bicocca*, Milano, Italy, Amount: 5,000 € (2 months).  
 Advisor: Gianluca Della Vedova  
 Studying phylogenetic models and how they can be used to model the evolution of tumours. This project resulted in a publication at CiE 2017

### Teaching Experience

- Spring 2022 **Georgia State University**.  
 ○ CSC 4330 / 6330 — a senior year / masters-level programming language concepts course
- Fall 2021 **Georgia State University**.  
 ○ CSC 4710 / 6710 — a senior year / masters-level course on database systems
- Spring 2021 **Georgia State University**.  
 ○ CSC 4330 / 6330 — a senior year / masters-level programming language concepts course

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- Fall 2020 **Georgia State University.**  
 ○ CSC 4330 / 6330 — a senior year / masters-level programming language concepts course
- Spring 2020 **Fairfield University.**  
 ○ CS 131 — an introductory programming course in Java, and  
 ○ CS 354 — a junior year theory of programming languages course using Haskell and Prolog
- Fall 2019 **Fairfield University.**  
 ○ CS 131 — an introductory programming course in Java  
 ○ CS 231 — an intermediate (sophomore year) programming course, focusing on the object-oriented features of Java, and  
 ○ SW 402 — a senior-year / masters-level course on database management systems
- 2015 **Instructor, Department of Mathematics, Université Claude Bernard Lyon 1, Villeurbanne, France.**  
 Section head: Raymond Lobry  
 Teaching a section of mathematics for the life sciences to first-year university students

### Advising

- Spring 2022 PhD students Zahra Tayebi, Sarwan Ali and Prakash Chourasia, and Master's students Babatunde Bello and Supriya Arun
- Fall 2021 PhD students Zahra Tayebi, Sarwan Ali and Prakash Chourasia, Master's students Babatunde Bello and Kaustubh Khandai, and Honors student Yijing Zhou. Sarwan Ali won an MBD fellowship, funding the remainder of his study. Yijing Zhou graduated with honors thesis titled: "Towards a complete workflow for inferring tumor phylogeny from raw single-cell sequencing reads"
- Spring 2021 PhD students Zahra Tayebi and Sarwan Ali
- Fall 2020 PhD student Zahra Tayebi

### Volunteer Experience

- 2017—2019 **Research Advisor, Lycée Stendhal, Milan, Italy.**  
 Advising and guiding students on an after-school mathematics project which is part of the larger European program: Math en Jeans. There is an annual conference where the students go to present their work on the year's project.

### Grants

- 2021 **Global Education Online Module Design, Hanyang University ERICA, Amount: \$30,195 USD (3 years).**  
 PI: Zhipeng Cai  
 For the development of online modules in data science and business intelligence, which could be offered as a course or training program

### Awards

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- 2011 The Marie Curie Alain Bensoussan (ABCDE) Postdoctoral Fellowship of the European Research Consortium for Informatics and Mathematics (ERCIM)  
Award of 60,300 € and 5000 € for travel, in order to fully fund 2 years of postdoctoral study in the European ERCIM member countries
- 2006 The Postgraduate Scholarship (PGS) of the Natural Sciences and Engineering Research Council (NSERC) of Canada  
Award of \$63,000 CAD in order to fully fund 3 years of postgraduate (PhD) research
- 2006 Simon Fraser University Computing Science Graduate Fellowship  
Award of \$3000 CAD towards funding postgraduate research
- 2005 Simon Fraser University Computing Science Graduate Fellowship  
Award of \$3000 CAD towards funding postgraduate research
- 2002 The Undergraduate Student Research Award (USRA) of the Natural Sciences and Engineering Research Council (NSERC) of Canada  
Award of \$6400 CAD in order to fully fund a summer of undergraduate research

## Technical Skills

advanced	C/C++, Python, $\text{\LaTeX}$	7+ years experience
intermediate	Java, Unix tools, Shell programming	4+ years experience
basic	Matlab, R, Prolog, Haskell	2+ years experience

## Languages

English	maternal language	
French	second language	conversational and technical fluency
Italian	intermediate	comprehension and basic conversational skills
Spanish	intermediate	comprehension and basic conversational skills
中文	basic	basic words and phrases

## Publications

### Journal Articles

1. Sarwan Ali, Babatunde Bello, Zahra Tayebi, and Murray Patterson. Characterizing SARS-CoV-2 spike sequences based on geographical location. *Journal of Computational Biology*, 2022. to appear.
2. Sarwan Ali, Bikram Sahoo, Muhammad Asad Khan, Alexander Zelikovsky, Imdad Ullah Khan\*, and Murray Patterson\*. Efficient approximate kernel based spike sequence classification. *Transactions on Computational Biology and Bioinformatics*, 2022. to appear.

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3. Kaustubh Khandai, Cristian Navarro-Martinez, Brendan Smith, Rebecca Buonopane, S. Ashley Byun\*, and Murray Patterson\*. Determining significant correlation between pairs of extant characters in a small parsimony framework. *Journal of Computational Biology*, 29(10):1132–1154, 2022. doi:10.1089/cmb.2022.0141.
4. Sarwan Ali, Babatunde Bello, Prakash Chourasia, Ria Thazhe Punathil, Yijing Zhou, and Murray Patterson. PWM2Vec: An efficient embedding approach for viral host specification from coronavirus spike sequences. *MDPI Biology*, 11(3):418, 2022. doi:10.3390/biology11030418.
5. Sarwan Ali, Yijing Zhou, and Murray Patterson. Efficient analysis of COVID-19 clinical data using machine learning models. *Medical & Biological Engineering & Computing*, 60(7):1881–1896, 2021. doi:10.1007/s11517-022-02570-8.
6. Zahra Tayebi, Sarwan Ali, and Murray Patterson. Robust representation and efficient feature selection allows for effective clustering of SARS-CoV-2 variants. *Algorithms*, 14(12):348, 2021. doi:10.3390/a14120348.
7. Sarwan Ali, Simone Ciccolella, Lorenzo Lucarella, Gianluca Della Vedova, and Murray Patterson. Simpler and faster development of tumor phylogeny pipelines. *Journal of Computational Biology*, 28(11):1142–1155, 2021. doi:10.1089/cmb.2021.0271.
8. Andrew Melnyk, Fatemeh Mohebbi, Sergey Knyazev, Bikram Sahoo, Roya Hosseini, Pavel Skums, Alex Zelikovsky\*, and Murray Patterson\*. From alpha to zeta: Identifying variants and subtypes of SARS-CoV-2 via clustering. *Journal of Computational Biology*, 28(11):1113–1129, 2021. doi:10.1089/cmb.2021.0302.
9. Simone Ciccolella\*, Murray Patterson\*, Paola Bonizzoni, and Gianluca Della Vedova. Effective clustering for single cell sequencing cancer data. *IEEE Journal of Biomedical and Health Informatics*, 25(11):4068–4078, 2021. doi:10.1109/JBHI.2021.3081380.
10. Simone Ciccolella, Mauricio Soto, Murray D. Patterson, Gianluca Della Vedova, Iman Hajirasouliha, and Paola Bonizzoni. Gpps: An ILP-based approach for inferring cancer progression with mutation losses from single cell data. *BMC Bioinformatics*, 21(1):413, 2020. doi:10.1186/s12859-020-03736-7.
11. Simone Ciccolella, Camir Ricketts, Mauricio Soto Gomez, Murray Patterson, Dana Silverbush, Paola Bonizzoni, Iman Hajirasouliha, and Gianluca Della Vedova. Inferring cancer progression from single-cell sequencing while allowing mutation losses. *Bioinformatics*, 37(3):326–333, 2020. doi:10.1093/bioinformatics/btaa722.
12. Raffaella Rizzi, Stefano Beretta, Murray Patterson, Yuri Pirola, Marco Previtali, Gianluca Della Vedova, and Paola Bonizzoni. Overlap graphs and de Bruijn graphs: data structures for de novo genome assembly in the big data era. *Quantitative Biology*, 7(4):278–292, 2019. doi:10.1007/s40484-019-0181-x.
13. Stefano Beretta\*, Murray Patterson\*, Simone Zaccaria, Gianluca Della Vedova, and Paola Bonizzoni. HapCHAT: Adaptive haplotype assembly for efficiently leveraging high coverage in long reads. *BMC Bioinformatics*, 19(1):252, 2018. doi:10.1186/s12859-018-2253-8.

14. Wandrille Duchemin, Yoann Anselmetti, Murray Patterson, Yann Ponty, S  verine B  rard, Cedric Chauve, Celine Scornavacca, Vincent Daubin, and Eric Tannier. DeCoSTAR: Reconstructing the ancestral organization of genes or genomes using reconciled phylogenies. *Genome Biology and Evolution*, 9(5):1312–1319, 2017. doi:10.1093/gbe/evx069.
15. Andrea Bracciali, Marco Aldinucci, Murray Patterson, Tobias Marschall, Nadia Pisanti, Ivan Merelli, and Massimo Torquati. PWhatsHap: Efficient haplotyping for future generation sequencing. *BMC Bioinformatics*, 17(11):342, 2016. doi:10.1186/s12859-016-1170-y.
16. Murray Patterson\*, Tobias Marschall\*, Nadia Pisanti, Leo van Iersel, Leen Stougie, Gunnar W. Klau<sup>†</sup>, and Alexander Schoenhuth<sup>†</sup>. WhatsHap: Weighted haplotype assembly for future-generation sequencing reads. *Journal of Computational Biology*, 22(6):498–509, 2015. doi:10.1089/cmb.2014.0157.
17. Murray Patterson, Gergely Sz  ll  si, Vincent Daubin, and Eric Tannier. Lateral gene transfer, rearrangement, reconciliation. *BMC Bioinformatics*, 14(15):S4, 2013. doi:10.1186/1471-2105-14-S15-S4.
18. Mohammed El-Kebir\*, Tobias Marschall\*, Inken Wohlers\*, Murray Patterson, Jaap Heringa, Alexander Schoenhuth, and Gunnar W. Klau. Mapping proteins in the presence of paralogs using units of coevolution. *BMC Bioinformatics*, 14(15):S18, 2013. doi:10.1186/1471-2105-14-S15-S18.
19. J  n Ma  uch\*, Murray Patterson\*, Roland Wittler\*, Cedric Chauve, and Eric Tannier. Linearization of ancestral multichromosomal genomes. *BMC Bioinformatics*, 13(19):S11, 2012. doi:10.1186/1471-2105-13-S19-S11.
20. J  n Ma  uch\*, Murray Patterson\*, and Cedric Chauve. Hardness results on the gapped consecutive-ones property problem. *Discrete Applied Mathematics*, 160(18):2760–2768, 2012. doi:10.1016/j.dam.2012.03.019.
21. J  n Ma  uch\* and Murray Patterson\*. The complexity of the gapped consecutive-ones property problem for matrices of bounded maximum degree. *Journal of Computational Biology*, 18(9):1243–1253, 2011. doi:10.1089/cmb.2011.0128.
22. Roland Wittler, J  n Ma  uch\*, Murray Patterson\*, and Jens Stoye. Consistency of sequence-based gene clusters. *Journal of Computational Biology*, 18(9):1023–1039, 2011. doi:10.1089/cmb.2011.0083.

### Conference Proceedings

23. Sarwan Ali, Taslim Murad, and Murray Patterson. PSSM2Vec: A compact alignment-free embedding approach for coronavirus spike sequence classification. In *the 29th International Conference on Neural Information Processing (ICONIP, Indore, India, 2022)*, Springer CCIS. 2022. to appear.
24. Taslim Murad\*, Prakash Chourasia\*, Sarwan Ali\*, and Murray Patterson. Hashing2Vec: Fast embedding generation for SARS-CoV-2 spike sequence classification. In *the 14th Asian Conference on Machine Learning (ACML, Hyderabad, India, 2022)*, PMLR. 2022. to appear.

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25. Prakash Chourasia, Sarwan Ali, Simone Ciccolella, Gianluca Della Vedova, and Murray Patterson. Clustering SARS-CoV-2 variants from raw high-throughput sequencing reads data. In *the 11th International Conference on Computational Advances in Bio and medical Sciences (ICCABS, Virtual Conference, 2021)*, Springer LNBI. 2022. to appear.
26. Sarwan Ali, Taslim Murad, Prakash Chourasia, and Murray Patterson. Spike2Signal: Classifying coronavirus spike sequences with deep learning. In *the 8th IEEE International Conference on Big Data Service and Applications (IEEE BDS, San Francisco Bay Area, USA, 2022)*, 81–88. 2022. doi:10.1109/BigDataService55688.2022.00020.
27. Sarwan Ali, Bikram Sahoo, Naimat Ullah, Alex Zelikovsky, Murray Patterson\*, and Imdad Ullah Khan\*. A  $k$ -mer based approach for SARS-CoV-2 variant identification. In *the 17th International Symposium on Bioinformatics Research and Applications (ISBRA, Shenzhen, China, 2021)*, volume 13064 of LNCS, 153–164. 2021. doi:10.1007/978-3-030-91415-8\_14.
28. Brendan Smith, Cristian Navarro-Martinez, Rebecca Buonopane, S. Ashley Byun\*, and Murray Patterson\*. Correlated evolution in the small parsimony framework. In *the 17th International Symposium on Bioinformatics Research and Applications (ISBRA, Shenzhen, China, 2021)*, volume 13064 of LNCS, 608–619. 2021. doi:10.1007/978-3-030-91415-8\_51.
29. Sarwan Ali and Murray Patterson. Spike2Vec: An efficient and scalable embedding approach for COVID-19 spike sequences. In *the 2021 IEEE International Conference on Big Data (IEEE BigData, Virtual Conference, 2021)*, 1533–1530. 2021. doi:10.1109/BigData52589.2021.9671848.
30. Sarwan Ali, Tamkanat-E-Ali, Muhammad Asad Khan, Imdad Ullah Khan, and Murray Patterson. Effective and scalable clustering of SARS-CoV-2 sequences. In *the 5th International Conference on Big Data Research (ICBDR, Tokyo, Japan, 2021)*, 42–49. 2021. doi:10.1145/3505745.3505752.
31. Andrew Melnyk, Fatemeh Mohebbi, Sergey Knyazev, Bikram Sahoo, Roya Hosseini, Pavel Skums, Alex Zelikovsky\*, and Murray Patterson\*. Clustering based identification of SARS-CoV-2 subtypes. In *the 10th International Conference on Computational Advances in Bio and Medical Sciences (ICCABS, Virtual Conference, 2020)*, volume 12686 of LNCS, 127–141. 2021. doi:10.1007/978-3-030-79290-9\_11.
32. Simone Ciccolella\*, Murray Patterson\*, Paola Bonizzoni, and Gianluca Della Vedova. Effective clustering for single cell sequencing cancer data. In *the 10th ACM International Conference on Bioinformatics, Computational Biology and Health Informatics (ACM-BCB, Niagara Falls, NY, USA, 2019)*, ACM, 437–446. 2019. doi:10.1145/3307339.3342149.
33. Giulia Bernardini\*, Paola Bonizzoni\*, Gianluca Della Vedova\*, and Murray Patterson\*. A rearrangement distance for fully-labelled trees. In *the 30th Annual Symposium on Combinatorial Pattern Matching (CPM, Pisa, Italy, 2019)*, volume 128 of LIPIcs, 1–15. 2019. doi:10.4230/LIPIcs.CPM.2019.28.

34. Gianluca Della Vedova\*, Murray Patterson\*, Raffaella Rizzi\*, and Mauricio Soto\*. Character-based phylogeny construction and its application to tumor evolution. In *the 13th Conference on Computability in Europe (CiE, Turku, Finland, 2017)*, volume 10307 of LNCS, 3–13. 2017. doi:10.1007/978-3-319-58741-7\_1.
35. Marco Aldinucci, Andrea Bracciali, Tobias Marschall, Murray Patterson, Nadia Pisanti, and Massimo Torquati. High-performance haplotype assembly. In *the 11th International Meeting on Computational Intelligence Methods for Bioinformatics and Biostatistics (CIBB, Cambridge, UK, 2014)*, volume 8623 of LNCS, 245–258. 2015. doi:10.1007/978-3-319-24462-4\_21.
36. Murray Patterson\*, Tobias Marschall\*, Nadia Pisanti, Leo van Iersel, Leen Stougie, Gunnar W. Klau<sup>†</sup>, and Alexander Schoenhuth<sup>†</sup>. WhatsHap: Haplotype assembly for future-generation sequencing reads. In *the 18th Annual International Conference on Research in Computational Molecular Biology (RECOMB, Pittsburgh PA, USA, 2014)*, volume 8394 of LNCS, 237–249. 2014. doi:10.1007/978-3-319-05269-4\_19.
37. Cedric Chauve\*, Murray Patterson\*, and Ashok Rajaraman\*. Hypergraph covering problems motivated by genome assembly questions. In *the International Workshop on Combinatorial Algorithms (IWOCA, Rouen, France, 2013)*, volume 8288 of LNCS, 428–432. 2013. doi:10.1007/978-3-642-45278-9\_37.
38. Cedric Chauve\*, Ján Maňuch\*, Murray Patterson\*, and Roland Wittler\*. Tractability results for the consecutive-ones property with multiplicity. In *the 22nd Annual Symposium on Combinatorial Pattern Matching (CPM, Palermo, Italy, 2011)*, volume 6661 of LNCS, 90–103. 2011. doi:10.1007/978-3-642-21458-5\_10.
39. Ján Maňuch\*, Murray Patterson\*, and Arvind Gupta. Towards a characterization of the generalized cladistic character compatibility problem for non-branching character trees. In *the 7th International Symposium on Bioinformatics Research and Applications (ISBRA, Changsha, China, 2011)*, volume 6674 of LNCS, 440–451. 2011.
40. Ján Maňuch\*, Murray Patterson\*, Sheung-Hung Poon\*, and Chris Thachuk\*. Complexity of finding non-planar rectilinear drawings of graphs. In *the 18th International Symposium on Graph Drawing (GD, Konstanz, Germany, 2010)*, volume 6502 of LNCS, 305–316. 2010. doi:10.1007/978-3-642-18469-7\_28.
41. Cedric Chauve\*, Ján Maňuch\*, and Murray Patterson\*. On the gapped consecutive-ones property. In *the European Conference on Combinatorics, Graph Theory and Applications (EuroComb, Bordeaux, France, 2009)*, volume 34 of ENDM, 121–125. 2009. doi:10.1016/j.endm.2009.07.020.
42. Ján Maňuch\*, Murray Patterson\*, and Arvind Gupta. On the generalised character compatibility problem for non-branching character trees. In *the 15th Annual International Computing and Combinatorics Conference (COCOON, Niagara Falls, USA, 2009)*, volume 5609 of LNCS, 268–276. 2009. doi:10.1007/978-3-642-02882-3\_27.



43. Murray Patterson, Yongmei Liu, Eugenia Ternovska, and Arvind Gupta. Grounding for model expansion in  $k$ -guarded formulas with inductive definitions. In *the 20th International Joint Conferences on Artificial Intelligence (IJCAI, Hyderabad, India, 2007)*, 161–166. 2007.

note In any publication listing containing a \*, this indicates that all authors whose names are followed by a \* have contributed equally to this publication. In order to be consistent, this means that for papers that list the names of authors alphabetically (which is a common practice amongst computer science and theoretical bioinformatics papers), there is a \* following every name.

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