FINAL EXAM
ECEN 446 – Neural Networks
Information Theory, Inference, and Learning Algorithms

Joseph J. Boutros, 11 July 2021

Three Problems in Inference and Neural Networks   (100 points)

Textbooks, lecture notes, scientific calculators are allowed. Laptops and tablets are only authorized for consulting class notes, for visiting ECEN 446 web page, and for running Jupyter-Notebook, Python 3, Pari/gp or WolframAlpha/Mathematica software. Cellphones and chat applications are forbidden, they should stay away from your desk. Total time duration is 120 minutes.

Part I – Information Theory (20 points)

We recall that, for a discrete random variable $X \in \mathcal{X} = \{x_1, x_2, \ldots, x_M\}$, the entropy of X is defined as

$$H(X) = -\sum_{x \in \mathcal{X}} \mathbb{P}(X = x) \log(\mathbb{P}(X = x))$$

$$= -\sum_{x \in \mathcal{X}} p_X(x) \log(p_X(x)) = -\sum_{i=1}^{M} p_i \log(p_i), \tag{1}$$

where $p_X(x)$ is the probability mass function of X and $p_i = \mathbb{P}(X = x_i) = p_X(x_i)$, $i = 1 \ldots M$. Here, the integer M could be finite or infinite (to be replaced by ∞), e.g. if X is Poisson. For continuous random variables, we recall the similar definition of differential entropy

$$h(X) = -\int_{-\infty}^{\infty} p_X(x) \log(p_X(x)) \, dx, \tag{2}$$

where $p_X(x)$ is the probability density function of X, $X \in \mathbb{R}$.

(a) Let $X_1 \sim Bernoulli(p_1)$ and $X_2 \sim Bernoulli(p_2)$, X_1 and X_2 independent. Define $S = X_1 + X_2$, where the sum is modulo 2. Find the expression of the entropy of S as a function of p_1 and p_2.
Hint: Determine $\mathbb{P}(S = 0)$ and $\mathbb{P}(S = 1)$.

(b) Compute $H(S)$ for $p_1 = 1/2$ and any p_2. Compute $H(S)$ for $p_1 = p_2 = 1/4$. Does the entropy increase after modulo 2 addition?
Hint: Compare $H(S)$ to $H(X_1)$.

(c) Now $S = X_1 + X_2$ where $+$ is the standard addition in $\mathbb{R}$. The two random variables are not independent, their joint distribution is given by the following table

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Leonard Barolli,Flora Amato,Francesco Moscato,Tomoya Enokido,Makoto Takizawa

Neural Networks Final Exam:

Big Data and Internet of Things Oussama Mahboub,Khalid Haddouch,Hicham Omara,Mostafa Hefnawi,2025-01-02 Big Data and Internet of Things is the latest volume in the renowned Lecture Notes in Networks and Systems series This book compiles the latest research presented at the Seventh International Conference on Big Data and Internet of Things BDIoT 24 showcasing innovative solutions emerging trends and practical applications in the fields of big data and IoT An essential read for researchers professionals and students looking to stay ahead in the rapidly evolving world of technology The series contains proceedings and edited volumes in systems and networks spanning the areas of Cyber Physical Systems Autonomous Systems Sensor Networks Control Systems Energy Systems Automotive Systems Biological Systems Vehicular Networking and Connected Vehicles Aerospace Systems Automation Manufacturing Smart Grids Nonlinear Systems Power Systems Robotics Social Systems Economic Systems and other The series covers the theory applications and perspectives on the state of the art and future developments relevant to systems and networks decision making control complex processes and related areas as embedded in the fields of interdisciplinary and applied sciences engineering computer science physics economics social and life sciences as well as the paradigms and methodologies behind them **Artificial Intelligence in China** Wei Wang,Jiasong Mu,Xin Liu,Zhenyu Na Na,2024-03-22 This book brings together papers presented at the 2023 The International Conference on Artificial Intelligence in China ChinaAI which provides a venue to disseminate the latest developments and to discuss the interactions and links between these multidisciplinary fields Spanning topics covering all topics in Artificial Intelligence with new development in China this book is aimed at undergraduate and graduate students in Electrical Engineering Computer Science and Mathematics researchers and engineers from academia and industry as well as government employees such as NSF DOD DOE **Web, Artificial Intelligence and Network Applications** Leonard Barolli,Flora Amato,Francesco Moscato,Tomoya Enokido,Makoto Takizawa,2020-03-30 This proceedings book presents the latest research findings and theoretical and practical perspectives on innovative methods and development techniques related to the emerging areas of Web computing intelligent systems and Internet computing The Web has become an important source of information and techniques and methodologies that extract quality information are of paramount importance for many Web and Internet applications Data mining and knowledge discovery play a key role in many of today s major Web applications such as e commerce and computer security Moreover Web services provide a new platform for enabling service oriented systems The emergence of large scale distributed computing paradigms such as cloud computing and mobile computing systems has opened many opportunities for collaboration services which are at the core of any information system Artificial intelligence AI is an area of computer science that builds intelligent systems and algorithms that work and react like humans AI techniques and computational intelligence are powerful tools for learning adaptation reasoning and planning and they have the potential to become enabling technologies for future intelligent networks Research

in the field of intelligent systems robotics neuroscience artificial intelligence and cognitive sciences is vital for the future development and innovation of Web and Internet applications Chapter An Event Driven Multi Agent System for Scalable Traffic Optimization is available open access under a Creative Commons Attribution 4 0 International License via link springer com *Proceedings of the Future Technologies Conference (FTC) 2021, Volume 2* Kohei Arai,2021-11-03 This book covers a wide range of important topics including but not limited to Technology Trends Computing Artificial Intelligence Machine Vision Communication Security e Learning and Ambient Intelligence and their applications to the real world The sixth Future Technologies Conference 2021 was organized virtually and received a total of 531 submissions from academic pioneering researchers scientists industrial engineers and students from all over the world After a double blind peer review process 191 submissions have been selected to be included in these proceedings One of the meaningful and valuable dimensions of this conference is the way it brings together a large group of technology geniuses in one venue to not only present breakthrough research in future technologies but also to promote discussions and debate of relevant issues challenges opportunities and research findings We hope that readers find the book interesting exciting and inspiring it provides the state of the art intelligent methods and techniques for solving real world problems along with a vision of the future research Deep Learning Classifiers with Memristive Networks Alex Pappachen James,2019-04-08 This book introduces readers to the fundamentals of deep neural network architectures with a special emphasis on memristor circuits and systems At first the book offers an overview of neuro memristive systems including memristor devices models and theory as well as an introduction to deep learning neural networks such as multi layer networks convolution neural networks hierarchical temporal memory and long short term memories and deep neuro fuzzy networks It then focuses on the design of these neural networks using memristor crossbar architectures in detail The book integrates the theory with various applications of neuro memristive circuits and systems It provides an introductory tutorial on a range of issues in the design evaluation techniques and implementations of different deep neural network architectures with memristors **Deep Learning Generalization** Liu Peng,2025-09-12 This book provides a comprehensive exploration of generalization in deep learning focusing on both theoretical foundations and practical strategies It delves deeply into how machine learning models particularly deep neural networks achieve robust performance on unseen data Key topics include balancing model complexity addressing overfitting and underfitting and understanding modern phenomena such as the double descent curve and implicit regularization The book offers a holistic perspective by addressing the four critical components of model training data model architecture objective functions and optimization processes It combines mathematical rigor with hands on guidance introducing practical implementation techniques using PyTorch to bridge the gap between theory and real world applications For instance the book highlights how regularized deep learning models not only achieve better predictive performance but also assume a more compact and efficient parameter space Structured to accommodate a progressive learning curve the

content spans foundational concepts like statistical learning theory to advanced topics like Neural Tangent Kernels and overparameterization paradoxes By synthesizing classical and modern views of generalization the book equips readers to develop a nuanced understanding of key concepts while mastering practical applications For academics the book serves as a definitive resource to solidify theoretical knowledge and explore cutting edge research directions For industry professionals it provides actionable insights to enhance model performance systematically Whether you re a beginner seeking foundational understanding or a practitioner exploring advanced methodologies this book offers an indispensable guide to achieving robust generalization in deep learning   Soft Computing Applications Valentina Emilia Balas,Lakhmi C. Jain,Marius Mircea Balas,Dumitru Baleanu,2023-10-26 Soft computing techniques open significant opportunities in several areas such as industry medicine energy security transportation and education This book provides theory and applications development using soft computing techniques by organizing intelligent systems for many applications to the benefit of humanity The book comes from a multidisciplinary subject whose audience can come from different academic departments e g department of computer science and engineering department of medical imaging department of biomedical informatics department of education sciences and so on where artificial intelligence and soft computing are of routine courses The book covers a range of audience from academicians practitioners researchers and students to stakeholders It can support graduate students and interns to develop a deep understanding of the latest paradigms in the soft computing techniques   Big Data in Education: Pedagogy and Research Theodosia Prodromou,2021-10-04 This book discusses how Big Data could be implemented in educational settings and research using empirical data and suggesting both best practices and areas in which to invest future research and development It also explores 1 the use of learning analytics to improve learning and teaching 2 the opportunities and challenges of learning analytics in education As Big Data becomes a common part of the fabric of our world education and research are challenged to use this data to improve educational and research systems and also are tasked with teaching coming generations to deal with Big Data both effectively and ethically The Big Data era is changing the data landscape for statistical analysis the ways in which data is captured and presented and the necessary level of statistical literacy to analyse and interpret data for future decision making The advent of Big Data accentuates the need to enable citizens to develop statistical skills thinking and reasoning needed for representing integrating and exploring complex information This book offers guidance to researchers who are seeking suitable topics to explore It presents research into the skills needed by data practitioners data analysts data managers statisticians and data consumers academics and provides insights into the statistical skills thinking and reasoning needed by educators and researchers in the future to work with Big Data This book serves as a concise reference for policymakers who must make critical decisions regarding funding and applications   **ICT and Critical Infrastructure: Proceedings of the 48th Annual Convention of Computer Society of India- Vol II** Suresh Chandra Satapathy,P. S. Avadhani,Siba K. Udgata,Sadasivuni Lakshminarayana,2013-10-19 This

volume contains 85 papers presented at CSI 2013 48th Annual Convention of Computer Society of India with the theme ICT and Critical Infrastructure The convention was held during 13th 15th December 2013 at Hotel Novotel Varun Beach Visakhapatnam and hosted by Computer Society of India Vishakhapatnam Chapter in association with Vishakhapatnam Steel Plant the flagship company of RINL India This volume contains papers mainly focused on Data Mining Data Engineering and Image Processing Software Engineering and Bio Informatics Network Security Digital Forensics and Cyber Crime Internet and Multimedia Applications and E Governance Applications **Proceedings of the IEEE 1989 National Aerospace and Electronics Conference, NAECON 1989** ,1989 **Global Advances in Engineering Education** J.P. Mohsen,Mohamed Y. Ismail,Hamid R. Parsaei,Waldemar Karwowski,2019-05-03 The engineering profession is at a critical juncture that requires reforming engineering education The supply of engineers is declining whereas the nature of the demand is changing Formulating a response to these challenges demands the adoption of new and innovative tools and methods for promoting the expansion of the community while supporting these evolving requirements Initiatives to entice and retain students are being employed to support growth objectives Modern technologies are reshaping reform efforts This book discusses the state of affairs in the field of engineering education and presents practical steps for addressing the challenges in order to march toward a brighter future Features Covers the latest state of engineering education in the North America Europe Middle East North Africa and Far East Asia Discusses advances in science technology engineering and mathematics and community engagement Outlines applications of digital technologies to enhance learning Provides advances in remote and online instructions for engineering education Presents discussions on innovation leadership and ethics IJCNN'93-Nagoya ,1993 **1995 IEEE International Conference on Neural Networks** ,1995 **Simulation Digest** ,1990 **Proceedings** ,1995 *Management Information Systems and Business Statistics* Richard Schwindt,1995 Government Reports Announcements & Index ,1995 Linguistics and Language Behavior Abstracts ,1994 **ASEE ... Profiles of Engineering & Engineering Technology Colleges** ,1998 *Schedule of Classes* University of California, San Diego,2003

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