Bayesian deep learning for uncertainty

Deterministic neural networks (NNs) learn a fixed set of weights,
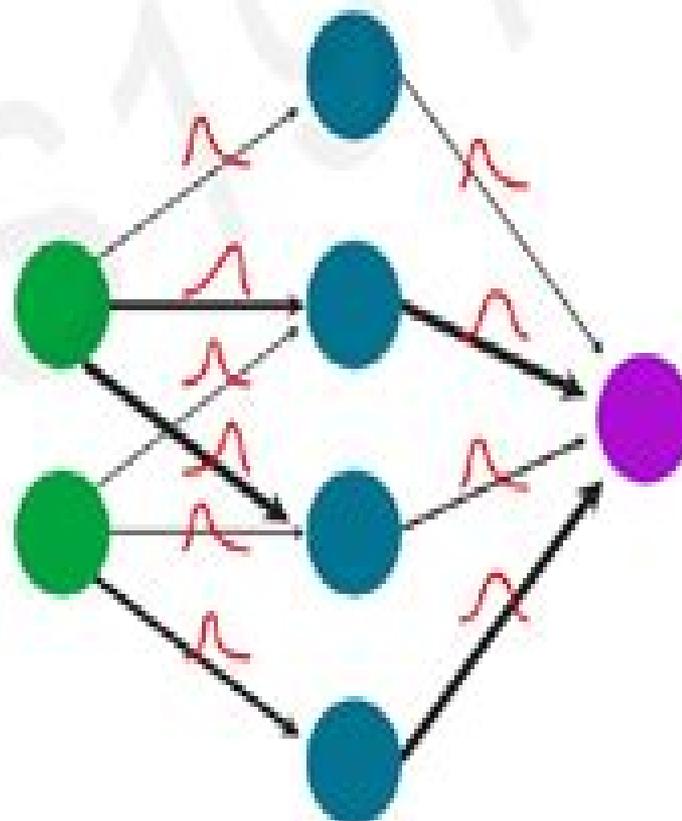
$$W$$

Bayesian neural networks aim to learn a posterior over weights,

$$P(W|X,Y)$$

$$P(W|X,Y) = \frac{P(Y|X,W)\,P(W)}{P(Y|X)}$$

Intractable!

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S Nieto

Bayesian Deep Learning Uncertainty In Deep Learning:

<u>Bayesian Deep Learning and Uncertainty in Computer Vision</u> Buu Truong Phan,2019 Visual data contains rich information about the operating environment of an intelligent robotic system Extracting this information allows intelligent systems to reason and decide their future actions Erroneous visual information therefore can lead to poor decisions causing accidents and casualties especially in a safety critical application such as automated driving One way to prevent this is by measuring the level of uncertainty in the visual information interpretation so that the system knows the reliability degree of the extracted information Deep neural networks are now being used in many vision tasks due to their superior accuracy compared to traditional machine learning methods However their estimated uncertainties have been shown to be unreliable To mitigate this issue researchers have developed methods and tools to apply Bayesian modeling to deep neural networks This results in a class of models known as Bayesian neural networks whose uncertainty estimates are more reliable and informative In this thesis we make the following contributions in the context of Bayesian Neural Network applied to vision tasks In particular We improve the understanding of visual uncertainty estimates from Bayesian deep models Specifically we study the behavior of Bayesian deep models applied to road scene image segmentation under different factors such as varying weather depth and occlusion levels We show the importance of model calibration technique in the context of autonomous driving which strengthens the reliability of the estimated uncertainty We demonstrate its effectiveness in a simple object localization task We address the high run time cost of the current Bayesian deep learning techniques We develop a distillation technique based on the Dirichlet distribution which allows us to estimate the uncertainties in real time

<u>Enhancing Deep Learning with Bayesian Inference</u> Matt Benatan,Jochem Gietema,Marian Schneider,2023-06-30 Develop Bayesian Deep Learning models to help make your own applications more robust Key Features Gain insights into the limitations of typical neural networks Acquire the skill to cultivate neural networks capable of estimating uncertainty Discover how to leverage uncertainty to develop more robust machine learning systems Book Description Deep learning has an increasingly significant impact on our lives from suggesting content to playing a key role in mission and safety critical applications As the influence of these algorithms grows so does the concern for the safety and robustness of the systems which rely on them Simply put typical deep learning methods do not know when they don t know The field of Bayesian Deep Learning contains a range of methods for approximate Bayesian inference with deep networks These methods help to improve the robustness of deep learning systems as they tell us how confident they are in their predictions allowing us to take more care in how we incorporate model predictions within our applications Through this book you will be introduced to the rapidly growing field of uncertainty aware deep learning developing an understanding of the importance of uncertainty estimation in robust machine learning systems You will learn about a variety of popular Bayesian Deep Learning methods and how to implement these through practical Python examples covering a range of application scenarios By the end of the book

you will have a good understanding of Bayesian Deep Learning and its advantages and you will be able to develop Bayesian Deep Learning models for safer more robust deep learning systems What you will learn Understand advantages and disadvantages of Bayesian inference and deep learning Understand the fundamentals of Bayesian Neural Networks Understand the differences between key BNN implementations approximations Understand the advantages of probabilistic DNNs in production contexts How to implement a variety of BDL methods in Python code How to apply BDL methods to real world problems Understand how to evaluate BDL methods and choose the best method for a given task Learn how to deal with unexpected data in real world deep learning applications Who this book is for This book will cater to researchers and developers looking for ways to develop more robust deep learning models through probabilistic deep learning You re expected to have a solid understanding of the fundamentals of machine learning and probability along with prior experience working with machine learning and deep learning models **Fully Bayesian Learning and Classic Deep Learning** Elio Abi Younes,2020 Classic deep learning algorithms are powerful tools for the construction of accurate predictive models for labeled data However traditional deep neural networks designed to learning such models are both prone to overfitting and incapable of assessing uncertainty In contrast Bayesian learning based upon the emergence of Markov chain Monte Carlo methods and variational inference provides strong ability to express uncertainty in predictions and improve the estimated posterior probability based on new evidence This work further assesses the efficiency and accuracy of Bayesian inference in complex settings We provide an in depth empirical analysis of the methods on both real and synthetic data in the context of regression and image classification Specifically we develop a unified Bayesian deep neural network model interleaving Bayesian sampling into deep learning By rephrasing these learning techniques upon a common theoretical ground casting 1 the application of fully Bayesian learning for deep neural networks rather than pure optimization based or approximate learning and 2 the most significant regularization technique in neural networks dropout as approximate Bayesian inference we perform a clear comparison proving the efficiency of Bayesian deep learning to maintain state of the art performance compared to existing methods while mitigating the problem of uncertainty in deep learning **Mathematical Analysis of Uncertainty in Machine Learning and Deep Learning** Takuya Kashimura,2020 In this paper we study uncertainty in machine learning and deep learning from the mathematical point of view Uncertainty is involved in many real world situations The Bayesian modelling can handle such uncertainty in machine learning community However the traditional deep learning model fails to show uncertainty for its outputs Recently at the intersection of the Bayesian modelling and deep learning a new framework called the Bayesian deep learning BDL has been proposed and studied which enables us to estimate uncertainty of deep learning models As an example of it we can review the results of Yarin Gal in which the famous dropout method can be seen as a Bayesian modelling We also see that overfitting problem of the framework due to the property of the KL divergence and review the modified algorithm using o divergence which generalizes the KL divergence

We also study a confidence band to assess uncertainty of a kernel ridge regression estimator We propose the formulation to obtain a confidence band as the convex optimization which enables us to use existing algorithms such as the primal dual inner point method The proposed method acquires a more accurate and fast confidence band than a bootstrap algorithm We also see the effectiveness of our proposed method both in the case of function approximation and an estimate of an actual dataset   ICPER 2020 Faiz Ahmad,Hussain H. Al-Kayiem,William Pao King Soon,2022-10-03 This book contains papers presented in the 7th International Conference on Production Energy and Reliability ICPER 2020 under the banner of World Engineering Science Technology Congress ESTCON2020 held from 14th to 16th July 2020 at Borneo Convention Centre Kuching Malaysia The conference contains papers presented by academics and industrial practitioners showcasing their latest advancements and findings in mechanical engineering areas with an emphasis on sustainability and the Industrial Revolution 4 0 The papers are categorized under the following tracks and topics of research IoT Reliability and Simulation Advanced Materials Corrosion and Autonomous Production Efficient Energy Systems and Thermofluids Production Manufacturing and Automotive   **AI and Digital Transformation: Innovations in Supply Chain, Education, and Energy Systems** Brahim El Bhiri,Amir Hussain,Yassine Maleh,2025-11-06 This book offers a comprehensive exploration of how artificial intelligence and digital technologies are revolutionizing key industries From optimizing supply chain logistics and enhancing educational frameworks to advancing sustainable energy solutions and predictive maintenance strategies this book provides invaluable insights into the future of industry and academia Divided into five thematic sections the book covers cutting edge research and practical applications in AI powered supply chains digital transformation in education and industry sustainable energy systems and advanced maintenance techniques Each chapter delves into innovative methodologies and real world case studies offering readers a roadmap to navigate the challenges and opportunities of the digital age Whether you re a researcher engineer or industry professional AI and Digital Transformation Innovations in Supply Chain Education and Energy Systems equips you with the knowledge and tools to harness the power of AI and digital technologies for a sustainable and efficient future This book is your guide to staying ahead in a rapidly evolving technological landscape

Artificial Intelligence and Machine Learning Toon Calders,Celine Vens,Jefrey Lijffijt,Bart Goethals,2023-09-04 This book contains a selection of the best papers of the 34th Benelux Conference on Artificial Intelligence BNAIC BENELEARN 2022 held in Mechelen Belgium in November 2022 The 11 papers presented in this volume were carefully reviewed and selected from 134 regular submissions They address various aspects of artificial intelligence such as natural language processing agent technology game theory problem solving machine learning human agent interaction AI and education and data analysis   Artificial Intelligence in Medicine Joseph Finkelstein,Robert Moskovitch,Enea Parimbelli,2024-07-26 This two volume set LNAI 14844 14845 constitutes the refereed proceedings of the 22nd International Conference on Artificial Intelligence in Medicine AIME 2024 held in Salt Lake City UT USA during July 9 12 2024 The 54 full papers and 22 short

papers presented in the book were carefully reviewed and selected from 335 submissions The papers are grouped in the following topical sections Part I Predictive modelling and disease risk prediction natural language processing bioinformatics and omics and wearable devices sensors and robotics Part II Medical imaging analysis data integration and multimodal analysis and explainable AI *Techniques in Mathematical Modelling* Gautami Devar,2025-02-20 Techniques in Mathematical Modelling is a comprehensive textbook designed to provide students researchers and practitioners with a solid foundation in the principles techniques and applications of mathematical modelling We cover a wide range of topics from fundamental concepts and analytical techniques to validation methods and emerging trends Each chapter includes practical examples case studies and exercises to reinforce learning and demonstrate real world applications Our book emphasizes the interdisciplinary nature of mathematical modelling with applications in physics biology economics engineering social sciences and more We encourage hands on learning through practical exercises simulations and projects allowing readers to apply theoretical concepts to real world scenarios Additionally we explore emerging trends and challenges in the field including advancements in computational techniques data analytics and interdisciplinary collaborations Written in clear and accessible language Techniques in Mathematical Modelling caters to readers with varying levels of mathematical background making it suitable for undergraduate and graduate students as well as professionals **Knowledge Guided Machine Learning** Anuj Karpatne,Ramakrishnan Kannan,Vipin Kumar,2022-08-15 Given their tremendous success in commercial applications machine learning ML models are increasingly being considered as alternatives to science based models in many disciplines Yet these black box ML models have found limited success due to their inability to work well in the presence of limited training data and generalize to unseen scenarios As a result there is a growing interest in the scientific community on creating a new generation of methods that integrate scientific knowledge in ML frameworks This emerging field called scientific knowledge guided ML KGML seeks a distinct departure from existing data only or scientific knowledge only methods to use knowledge and data at an equal footing Indeed KGML involves diverse scientific and ML communities where researchers and practitioners from various backgrounds and application domains are continually adding richness to the problem formulations and research methods in this emerging field Knowledge Guided Machine Learning Accelerating Discovery using Scientific Knowledge and Data provides an introduction to this rapidly growing field by discussing some of the common themes of research in KGML using illustrative examples case studies and reviews from diverse application domains and research communities as book chapters by leading researchers KEY FEATURES First of its kind book in an emerging area of research that is gaining widespread attention in the scientific and data science fields Accessible to a broad audience in data science and scientific and engineering fields Provides a coherent organizational structure to the problem formulations and research methods in the emerging field of KGML using illustrative examples from diverse application domains Contains chapters by leading researchers which illustrate the cutting edge research trends opportunities and

challenges in KGML research from multiple perspectives Enables cross pollination of KGML problem formulations and research methods across disciplines Highlights critical gaps that require further investigation by the broader community of researchers and practitioners to realize the full potential of KGML *Artificial Intelligence and Machine Learning for Digital Pathology* Andreas Holzinger,Randy Goebel,Michael Mengel,Heimo Müller,2020-06-24 Data driven Artificial Intelligence AI and Machine Learning ML in digital pathology radiology and dermatology is very promising In specific cases for example Deep Learning DL even exceeding human performance However in the context of medicine it is important for a human expert to verify the outcome Consequently there is a need for transparency and re traceability of state of the art solutions to make them usable for ethical responsible medical decision support Moreover big data is required for training covering a wide spectrum of a variety of human diseases in different organ systems These data sets must meet top quality and regulatory criteria and must be well annotated for ML at patient sample and image level Here biobanks play a central and future role in providing large collections of high quality well annotated samples and data The main challenges are finding biobanks containing fit for purpose samples providing quality related meta data gaining access to standardized medical data and annotations and mass scanning of whole slides including efficient data management solutions **Developing Deep Learning and Bayesian Deep Learning Based Models for MR Neuroimaging** Gengyan Zhao,2019 Magnetic resonance MR neuroimaging is an active field in investigating brain structures and functions After decades of development the whole pipeline of MR neuroimaging tends to become mature but many essential steps still faces challenges and difficulties especially in the accuracy of the image segmentation image generation and data prediction Recently the revival of deep neural networks made immense progress in the field of machine learning The proposal of Bayesian deep learning further enabled the ability of uncertainty generation in deep learning prediction In this work we proposed and developed different kinds of Bayesian neural networks to improve the accuracy of brain segmentation brain image synthesis and brain function related behavior prediction To overcome the challenges in brain segmentation we proposed a fully automated brain extraction pipeline combining deep Bayesian convolutional neural network CNN and fully connected three dimensional 3D conditional random field CRF To increase the image synthesis accuracy and improve the calibration of the model uncertainty we proposed a Bayesian conditional generative adversarial network GAN To improve the brain function related behavior prediction we proposed a Bayesian deep neural network DNN and a feature extraction and ranking method for it Experiments were done on real data to validate the proposed methods The comparison between our methods and the state of the arts showed that our methods can significantly improve the testing accuracy and the behavior of the model uncertainty generated by the Bayesian neural networks matches our expectation **Advances in Bayesian Model Selection and Uncertainty Estimation for Deep Learning** Alexander Immer,2024 Uncertainty Estimation for Dense Stereo Matching Using Bayesian Deep Learning Max Mehltretter,2021 *Towards Intelligent Operation of Future Power System* Tingqi

Zhang,2022   Epistemic Uncertainty in Artificial Intelligence Fabio Cuzzolin,Maryam Sultana,2024-04-23 This LNCS 14523 conference volume constitutes the proceedings of the First International Workshop Epi UAI 2023 in Pittsburgh PA USA August 2023 The 8 full papers together included in this volume were carefully reviewed and selected from 16 submissions Epistemic AI focuses in particular on some of the most important areas of machine learning unsupervised learning supervised learning and reinforcement learning   **Uncertainty for Safe Utilization of Machine Learning in Medical Imaging** Carole H. Sudre,Mobarak I. Hoque,Raghav Mehta,Cheng Ouyang,Chen Qin,Marianne Rakic,William M. Wells,2025-10-30 This book constitutes the refereed proceedings of the 7th Workshop on Uncertainty for Safe Utilization of Machine Learning in Medical Imaging UNSURE 2025 held in conjunction with MICCAI 2025 in Daejon South Korea on September 27 2025 The 22 full papers included in this book were carefully reviewed and selected from 33 submissions They were organized in topical sections as follows Risk management uncertainty interpretation and visualisation domain shift and out of distribution management uncertainty calibration and uncertainty modelling and estimation Bayesian deep learning   Uncertainty Predictions for Machine-learning-based Analysis of Anomalous Diffusion Henrik Seckler,2025* In this work we study the application of Bayesian deep learning to include uncertainty estimates in machine learning based analysis of anomalous diffusion After a detailed introduction where the concepts of both anomalous diffusion and machine learning are conveyed to the reader the three publications which form the core of this dissertation are presented In the first paper we utilise a Bayesian deep learning method named textit Stochastic Weight Averaging Gaussian SWAG to extend the machine learning solution to anomalous diffusion by adding error estimates to the predictions of the machine We show that this method provides accurate uncertainty estimates while maintaining the high performance of other machine learning solutions Additionally we demonstrate through a detailed analysis that the prediction behaviour of the machine can be linked to the properties of the underlying diffusion models In the second publication we provide an overview of the recent advancements in machine learning methods for anomalous   Uncertainty in Artificial Intelligence ,1996   **Variational Methods for Machine Learning with Applications to Deep Networks** Lucas Pinheiro Cinelli,Matheus Araújo Marins,Eduardo Antônio Barros da Silva,Sérgio Lima Netto,2021-05-10 This book provides a straightforward look at the concepts algorithms and advantages of Bayesian Deep Learning and Deep Generative Models Starting from the model based approach to Machine Learning the authors motivate Probabilistic Graphical Models and show how Bayesian inference naturally lends itself to this framework The authors present detailed explanations of the main modern algorithms on variational approximations for Bayesian inference in neural networks Each algorithm of this selected set develops a distinct aspect of the theory The book builds from the ground up well known deep generative models such as Variational Autoencoder and subsequent theoretical developments By also exposing the main issues of the algorithms together with different methods to mitigate such issues the book supplies the necessary knowledge on generative models for the reader to handle a wide range of data types sequential

or not continuous or not labelled or not The book is self contained promptly covering all necessary theory so that the reader does not have to search for additional information elsewhere Offers a concise self contained resource covering the basic concepts to the algorithms for Bayesian Deep Learning Presents Statistical Inference concepts offering a set of elucidative examples practical aspects and pseudo codes Every chapter includes hands on examples and exercises and a website features lecture slides additional examples and other support material

Whispering the Techniques of Language: An Emotional Quest through **Bayesian Deep Learning Uncertainty In Deep Learning**

In a digitally-driven earth where displays reign great and immediate transmission drowns out the subtleties of language, the profound strategies and emotional nuances concealed within phrases usually get unheard. However, situated within the pages of **Bayesian Deep Learning Uncertainty In Deep Learning** a interesting literary treasure pulsing with raw emotions, lies an extraordinary quest waiting to be undertaken. Composed by an experienced wordsmith, this charming opus attracts viewers on an introspective journey, lightly unraveling the veiled truths and profound affect resonating within the very material of each word. Within the mental depths of this touching evaluation, we will embark upon a heartfelt exploration of the book is key themes, dissect its fascinating writing style, and succumb to the effective resonance it evokes heavy within the recesses of readers hearts.

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