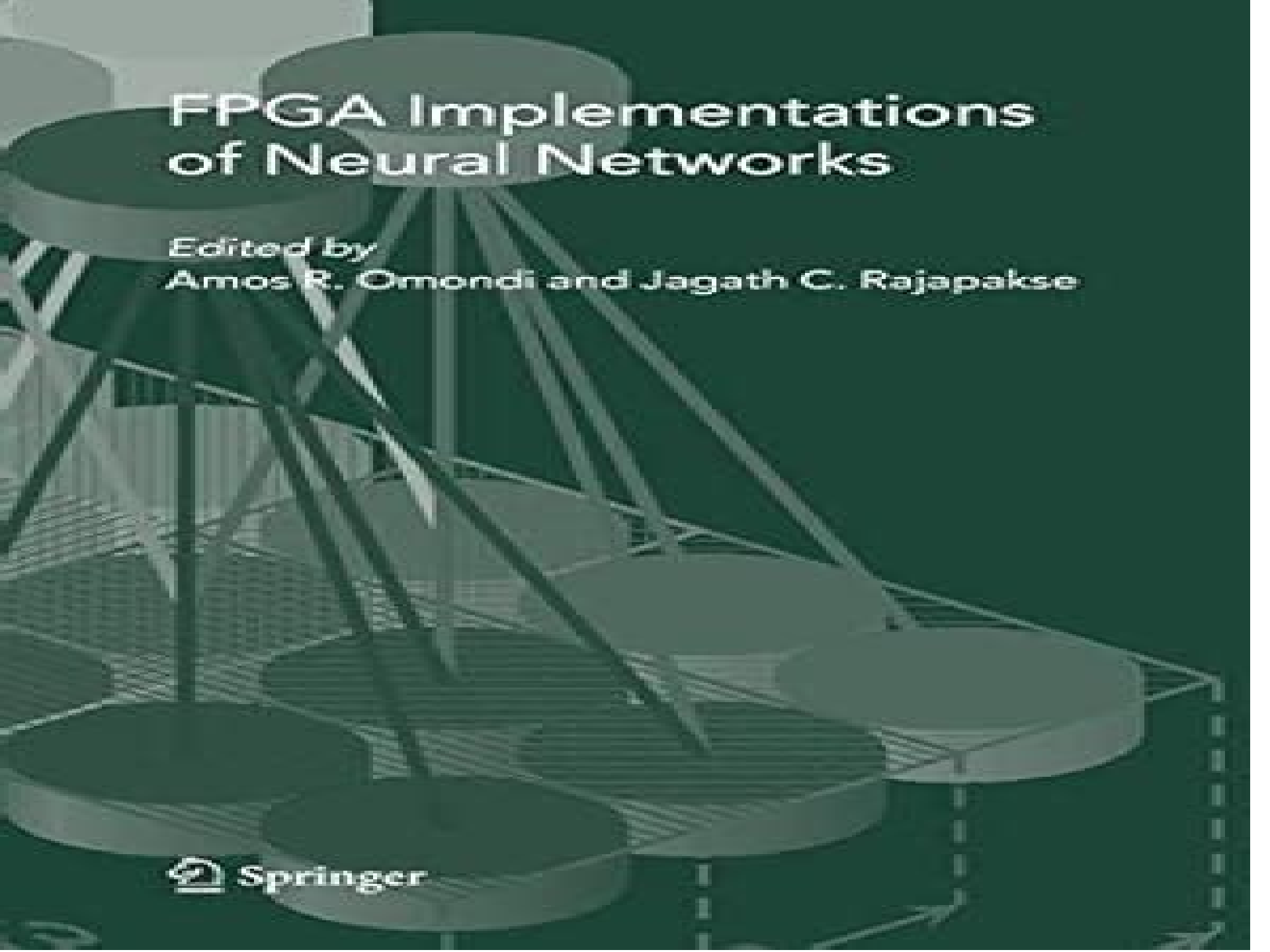




FPGA Implementations of Neural Networks

Edited by
Amos R. Omondi and Jagath C. Rajapakse

Fpga Implementations Of Neural Networks

**Reiner W. Hartenstein, Herbert
Grünbacher**



Fpga Implementations Of Neural Networks:

FPGA Implementations of Neural Networks Amos R. Omondi, Jagath C. Rajapakse, 2006-10-04 During the 1980s and early 1990s there was significant work in the design and implementation of hardware neurocomputers. Nevertheless, most of these efforts may be judged to have been unsuccessful at no time have hardware neurocomputers been in wide use. This lack of success may be largely attributed to the fact that earlier work was almost entirely aimed at developing custom neurocomputers based on ASIC technology but for such niche cases this technology was never sufficiently developed or competitive enough to justify large scale adoption. On the other hand, gate arrays of the period mentioned were never large enough nor fast enough for serious artificial neural network (ANN) applications. But technology has now improved the capacity and performance of current FPGAs are such that they present a much more realistic alternative. Consequently, neurocomputers based on FPGAs are now a much more practical proposition than they have been in the past. This book summarizes some work towards this goal and consists of 12 papers that were selected after review from a number of submissions. The book is nominally divided into three parts. Chapters 1 through 4 deal with foundational issues. Chapters 5 through 11 deal with a variety of implementations and Chapter 12 looks at the lessons learned from a large scale project and also reconsiders design issues in light of current and future technology.

FPGA Implementations of Neural Networks Amos R. Omondi, Jagath C. Rajapakse, 2008-11-01 During the 1980s and early 1990s there was significant work in the design and implementation of hardware neurocomputers. Nevertheless, most of these efforts may be judged to have been unsuccessful at no time have hardware neurocomputers been in wide use. This lack of success may be largely attributed to the fact that earlier work was almost entirely aimed at developing custom neurocomputers based on ASIC technology but for such niche cases this technology was never sufficiently developed or competitive enough to justify large scale adoption. On the other hand, gate arrays of the period mentioned were never large enough nor fast enough for serious artificial neural network (ANN) applications. But technology has now improved the capacity and performance of current FPGAs are such that they present a much more realistic alternative. Consequently, neurocomputers based on FPGAs are now a much more practical proposition than they have been in the past. This book summarizes some work towards this goal and consists of 12 papers that were selected after review from a number of submissions. The book is nominally divided into three parts. Chapters 1 through 4 deal with foundational issues. Chapters 5 through 11 deal with a variety of implementations and Chapter 12 looks at the lessons learned from a large scale project and also reconsiders design issues in light of current and future technology.

Field Programmable Logic and Application Jürgen Becker, Marco Platzner, Serge Vernalde, 2004-08-19 This book constitutes the refereed proceedings of the 14th International Conference on Field Programmable Logic (FPL 2003) held in Leuven, Belgium, in August-September 2004. The 78 revised full papers, 45 revised short papers and 29 poster abstracts presented together with 3 keynote contributions and 3 tutorial summaries were carefully reviewed and selected from 285 papers submitted. The papers

are organized in topical sections on organic and biologic computing security and cryptography platform based design algorithms and architectures acceleration application architecture physical design arithmetic multitasking circuit technology network processing testing applications signal processing computational models and compiler dynamic reconfiguration networks and optimisation algorithms system on chip high speed design image processing network on chip power aware design IP based design co processing architectures system level design physical interconnect computational models cryptography and compression network applications and architecture and debugging and test

FPGA Implementation of PSO Algorithm and Neural Networks Parviz Michael Palangpour, 2010 This thesis describes the Field Programmable Gate Array FPGA implementations of two powerful techniques of Computational Intelligence CI the Particle Swarm Optimization algorithm PSO and the Neural Network NN Particle Swarm Optimization PSO is a popular population based optimization algorithm While PSO has been shown to perform well in a large variety of problems PSO is typically implemented in software Population based optimization algorithms such as PSO are well suited for execution in parallel stages This allows PSO to be implemented directly in hardware and achieve much faster execution times than possible in software In this thesis a pipelined architecture for hardware PSO implementation is presented Benchmark functions solved by software and FPGA hardware PSO implementations are compared NNs are inherently parallel with each layer of neurons processing incoming data independently of each other While general purpose processors have reached impressive processing speeds they still cannot fully exploit this inherent parallelism due to their sequential architecture In order to achieve the high neural network throughput needed for real time applications a custom hardware design is needed In this thesis a digital implementation of an NN is developed for FPGA implementation The hardware PSO implementation is designed using only VHDL while the NN hardware implementation is designed using Xilinx System Generator Both designs are synthesized using Xilinx ISE and implemented on the Xilinx Virtex II Pro FPGA Development Kit Abstract leaf iii

FPGA Implementation of Reduced Precision Convolutional Neural Networks Muhammad Mohid Nabil, 2018 With the improvement in processing systems machine learning applications are finding widespread use in almost all sectors of technology Image recognition is one application of machine learning which has become widely popular with various architectures and systems aimed at improving recognition performance With classification accuracy now approaching saturation point many researchers are now focusing on resource and energy efficiency With the increased demand for learning applications in embedded devices it is of paramount importance to optimize power and energy consumption to increase utility in these low power embedded systems In recent months reduced precision neural networks have caught the attention of some researchers Reduced data width deep nets offer the potential of saving valuable resources on hardware platforms In turn these hardware platforms such as Field Programmable Gate Arrays FPGAs offer the potential of a low power system with massive parallelism increasing throughput and performance In this research we explore the implementations of a deep learning architecture on FPGA in the presence of

resource and energy constraints We study reduced precision neural networks and implement one such architecture as a proof of concept We focus on binarized convolutional neural network and its implementation on FPGAs Binarized convolutional nets have displayed a classification accuracy of up to 88% with some smaller image sets such as CIFAR 10 This number is on the rise with some of the new architectures We study the tradeoff between architecture depth and its impact on accuracy to get a better understanding of the convolutional layers and their impact on the overall performance This is done from a hardware perspective giving us better insight enabling better resource allocation on FPGA fabric Zynq ZCU 102 has been used for accelerator implementation High level synthesis tool Vivado HLS from Xilinx is used for CNN definition on FPGA fabric

Fpga Implementation of Hopfield Neural Network Avvaru Srinivasulu,2012-03 This work was to establish whether it was possible to achieve a reasonable speedup by implementing FPGA based Hopfield neural networks for some simple constraint satisfaction problems The results are significant our initial implementation using standard Xilinx FPGAs yielded 2 3 orders of magnitude speedup over the Sun Blade 2000 workstation comes with 1 2 GHz version of the 64 bit UltraSPARC III Cu processor The main problem with the work to date is that the problems are both unrealistically small and simplistic That is the constraints on the N Queen problem are simpler than those found in many real world scheduling applications Thus it is not clear whether we will be able to optimize the neuron structure for more complex problems since the weights matrix may not contain as many zero elements Thus a new method for speed improvement of Hopfield neural networks for solving constraint satisfaction problems using Field Programmable Gate Arrays FPGAs was proposed and implemented

Evolutionary Computing and Mobile Sustainable Networks V. Suma,Noureddine Bouhmala,Haoxiang Wang,2020-07-31 This book features selected research papers presented at the International Conference on Evolutionary Computing and Mobile Sustainable Networks ICECMSN 2020 held at the Sir M Visvesvaraya Institute of Technology on 20 21 February 2020 Discussing advances in evolutionary computing technologies including swarm intelligence algorithms and other evolutionary algorithm paradigms which are emerging as widely accepted descriptors for mobile sustainable networks virtualization optimization and automation this book is a valuable resource for researchers in the field of evolutionary computing and mobile sustainable networks

Application of FPGA to Real-Time Machine Learning Piotr Antonik,2018-05-18 This book lies at the interface of machine learning a subfield of computer science that develops algorithms for challenging tasks such as shape or image recognition where traditional algorithms fail and photonics the physical science of light which underlies many of the optical communications technologies used in our information society It provides a thorough introduction to reservoir computing and field programmable gate arrays FPGAs Recently photonic implementations of reservoir computing a machine learning algorithm based on artificial neural networks have made a breakthrough in optical computing possible In this book the author pushes the performance of these systems significantly beyond what was achieved before By interfacing a photonic reservoir computer with a high speed electronic device an FPGA

the author successfully interacts with the reservoir computer in real time allowing him to considerably expand its capabilities and range of possible applications Furthermore the author draws on his expertise in machine learning and FPGA programming to make progress on a very different problem namely the real time image analysis of optical coherence tomography for atherosclerotic arteries

Field-programmable Logic and Applications ,2000 *Enterprise Digital Transformation* Peter Augustine,Pethuru Raj,Sathyan Munirathinam,2022-02-17 Digital transformation DT has become a buzzword Every industry segment across the globe is consciously jumping toward digital innovation and disruption to get ahead of their competitors In other words every aspect of running a business is being digitally empowered to reap all the benefits of the digital paradigm All kinds of digitally enabled businesses across the globe are intrinsically capable of achieving bigger and better things for their constituents Their consumers clients and customers will realize immense benefits with real digital transformation initiatives and implementations The much awaited business transformation can be easily and elegantly accomplished with a workable and winnable digital transformation strategy plan and execution There are several enablers and accelerators for realizing the much discussed digital transformation There are a lot of digitization and digitalization technologies available to streamline and speed up the process of the required transformation Industrial Internet of Things IIoT technologies in close association with decisive advancements in the artificial intelligence AI space can bring forth the desired transitions The other prominent and dominant technologies toward forming digital organizations include cloud IT edge fog computing real time data analytics platforms blockchain technology digital twin paradigm virtual and augmented reality VR AR techniques enterprise mobility and 5G communication These technological innovations are intrinsically competent and versatile enough to fulfill the varying requirements for establishing and sustaining digital enterprises Enterprise Digital Transformation Technology Tools and Use Cases features chapters on the evolving aspects of digital transformation and intelligence It covers the unique competencies of digitally transformed enterprises IIoT use cases and applications It explains promising technological solutions widely associated with digital innovation and disruption The book focuses on setting up and sustaining smart factories that are fulfilling the Industry 4 0 vision that is realized through the IIoT and allied technologies

Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications Eduardo Bayro-Corrochano,Edwin Hancock,2014-10-23 This book constitutes the refereed proceedings of the 19th Iberoamerican Congress on Pattern Recognition CIARP 2014 held in Puerto Vallarta Jalisco Mexico in November 2014 The 115 papers presented were carefully reviewed and selected from 160 submissions The papers are organized in topical sections on image coding processing and analysis segmentation analysis of shape and texture analysis of signal speech and language document processing and recognition feature extraction clustering and classification pattern recognition and machine learning neural networks for pattern recognition computer vision and robot vision video segmentation and tracking

Artificial Neural Networks ,2002 **Embedded Computer Systems: Architectures, Modeling, and Simulation**

Cristina Silvano,Christian Pilato,Marc Reichenbach,2023-11-06 This book constitutes the proceedings of the 22st International Conference on Embedded Computer Systems Architectures Modeling and Simulation SAMOS 2021 which took place in July 2022 in Samos Greece The 11 full papers and 7 short papers presented in this volume were carefully reviewed and selected from 45 submissions The conference covers a wide range of embedded systems design aspects including machine learning accelerators and power management and programmable dataflow systems

FPGA Implementation of Backpropagation Algorithm of Artificial Neural Networks ,2017 Back Propagation BP Algorithm is one of the efficient learning algorithms for the training of Artificial Neural Networks ANN The efficient hardware implementation of the BP Algorithm can find its application in the broad field of applications The common computing platforms to build the BP algorithm based ANN Systems are Application Specific Integrated Circuits ASICs and General Purpose Processors GPP based computers However due to a high demand of maintaining a trade off between performance and flexibility such computing machines become a bottleneck for further advanced improvements In the last few decades there has been significant progress in the field of Field Programmable Gate Arrays FPGAs which are based on the reconfigurable hardware platform One of the main advantages of FPGAs are its flexibility it is possible to reprogram the same hardware and achieve good performance by allowing parallel computation at the same time The focus of this thesis is to implement the BP algorithm based ANN system on reconfigurable platform FPGA The proposed designs are coded on the software platform MATLAB and in Verilog Hardware Description Language Verilog HDL on FPGA and synthesized on artix 7 FPGA evaluation kit The validation of the design is verified on two benchmarks and comparisons are observed and discussed between two platforms

FPGA Implementation of a Wavelet Neural Network with Learning Ability ,2006

Understanding and Bridging the Gap between Neuromorphic Computing and Machine Learning, volume II Huajin Tang,Lei Deng ,Kaushik Roy,2024-08-26 Towards the long standing dream of artificial intelligence two solution paths have been paved i neuroscience driven neuromorphic computing ii computer science driven machine learning The former targets at harnessing neuroscience to obtain insights for brain like processing by studying the detailed implementation of neural dynamics circuits coding and learning Although our understanding of how the brain works is still very limited this bio plausible way offers an appealing promise for future general intelligence In contrast the latter aims at solving practical tasks typically formulated as a cost function with high accuracy by eschewing most neuroscience details in favor of brute force optimization and feeding a large volume of data With the help of big data e g ImageNet high performance processors e g GPU TPU effective training algorithms e g artificial neural networks with gradient descent training and easy to use design tools e g Pytorch Tensorflow machine learning has achieved superior performance in a broad spectrum of scenarios Although acclaimed for the biological plausibility and the low power advantage benefit from the spike signals and event driven processing there are ongoing debates and skepticisms about neuromorphic computing since it usually performs worse than machine learning in practical

tasks especially in terms of the accuracy **Design of a Neural Network for FPGA Implementation** Ee Ric Lim,2013
Advances in Neural Networks--ISNN ... ,2005 **International Symposium on Neuro-Fuzzy Systems** ,1996 This is a first conference describing advances in designing and using integrated circuits in control system The application of neural networks on VLSI is explored The Use of fuzzy logic in integrated circuit product controllers is explored *ICICCT 2019 - System Reliability, Quality Control, Safety, Maintenance and Management* Vinit Kumar Gunjan,Vicente Garcia Diaz,Manuel Cardona,Vijender Kumar Solanki,K. V. N. Sunitha,2019-06-27 This book discusses reliability applications for power systems renewable energy and smart grids and highlights trends in reliable communication fault tolerant systems VLSI system design and embedded systems Further it includes chapters on software reliability and other computer engineering and software management related disciplines and also examines areas such as big data analytics and ubiquitous computing Outlining novel innovative concepts in applied areas of reliability in electrical electronics and computer engineering disciplines it is a valuable resource for researchers and practitioners of reliability theory in circuit based engineering domains

The Top Books of the Year Fpga Implementations Of Neural Networks The year 2023 has witnessed a noteworthy surge in literary brilliance, with numerous engrossing novels captivating the hearts of readers worldwide. Lets delve into the realm of top-selling books, exploring the captivating narratives that have captivated audiences this year. Fpga Implementations Of Neural Networks : Colleen Hoover's "It Ends with Us" This touching tale of love, loss, and resilience has captivated readers with its raw and emotional exploration of domestic abuse. Hoover skillfully weaves a story of hope and healing, reminding us that even in the darkest of times, the human spirit can prevail. Uncover the Best : Taylor Jenkins Reids "The Seven Husbands of Evelyn Hugo" This spellbinding historical fiction novel unravels the life of Evelyn Hugo, a Hollywood icon who defies expectations and societal norms to pursue her dreams. Reids captivating storytelling and compelling characters transport readers to a bygone era, immersing them in a world of glamour, ambition, and self-discovery. Fpga Implementations Of Neural Networks : Delia Owens "Where the Crawdads Sing" This mesmerizing coming-of-age story follows Kya Clark, a young woman who grows up alone in the marshes of North Carolina. Owens crafts a tale of resilience, survival, and the transformative power of nature, captivating readers with its evocative prose and mesmerizing setting. These top-selling novels represent just a fraction of the literary treasures that have emerged in 2023. Whether you seek tales of romance, adventure, or personal growth, the world of literature offers an abundance of engaging stories waiting to be discovered. The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts. The Secret History is an exceptional and thrilling novel that will keep you guessing until the very end. The novel is a cautionary tale about the dangers of obsession and the power of evil.

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