

First Edition

Full Self-Driving, Skynet

and other AI Myths

Brad Flaughter

**Modern decision making
with deep machine
learning models**

Full Self-Driving, Skynet and Other Artificial Intelligence Myths

Modern decision making with deep machine learning models

Brad Flaughner

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We have now accumulated sufficient evidence to see that whatever language the central nervous system is using, it is characterized by less logical and arithmetical depth than what we are normally used to.

– John von Neumann [1]

Preface

This book is an attempt to organize my brain on paper. I have been thinking about decision making with computers, and the computer's relationship to the brain for too long now, and before I get dementia (I'm 35) I would like to put a stake in the ground and tell everyone where they can stick their thoughts about the future.

I am simultaneously very hopeful for the future and horrified by the way that people talk about it. I think many so-called "Data Scientists" are full of shit when they talk, and some of them know it but would like to keep their jobs. I think that many investors are snowed by fancy language and toy demos that they extrapolate into a magical future. Users of digital products are woefully ignorant about how the products work and how they fit into a larger ecosystem. I'm amused, annoyed and would like to clear things up for everyone, including myself.

I am a self-employed programmer and financially secure, these are my credentials. I have no corporate master and I am not raising money to create the future of AI, so have a limited bias towards AI boosterism. I write programs close enough to the bleeding-edge that I can see the present as fast as almost anyone. Because I am simultaneously a [contractor](#), [investor](#) and [teacher](#) I get the opportunity to see many projects, and I hope I can effectively comment on some common misconceptions and errors in thinking I see in many businesspeople, developers and investors.

So let's go on this journey together, I'll try and explain to you (with words, code and examples) how modern AI works, and when you should be scared (self-driving cars without the appropriate infrastructure) or when you should not be scared (please shut up about Skynet becoming self-aware). I'll also try do case studies in as many arenas that I think are interesting. If you have notes for me you can reach me at brad@bradflaughter.com.

Please skim this book, please skip around and read some stories. I think the first three chapters are important for everyone to know. The rest of the stories can be chosen a la carte. Enjoy.

Brad Flaugher

Contents

| | |
|---|------------|
| Preface | iii |
| Contents | iv |
| 1 History: The End of Good Old-Fashioned Artificial Intelligence | 1 |
| 1.1 The AI Textbook in 1997 | 1 |
| 1.2 Does AI Need to Know Grammar to Translate? | 1 |
| 1.3 Explicit Rules and Codified Human Knowledge | 2 |
| 1.4 IBM Tries Every Possible Chess Move | 4 |
| 1.5 Statistical Analysis of Handwriting is the Way of the Future | 4 |
| 1.6 Less Programmer Intelligence and more Data Intelligence | 5 |
| 1.7 From Explicit Rules to a Black Box, and Beyond | 5 |
| 1.8 Key Takeaways | 6 |
| 2 The Regression Theory of Everything | 7 |
| 2.1 Let's Avoid Knowledge Representation! | 7 |
| 2.2 A Simple Neural Network is also a Linear Regression | 8 |
| 2.3 Dummy Variables for Dummies (Wonkish) | 8 |
| 2.4 Try That Again With 33,640,010 Parameters | 10 |
| 2.5 Multicollinearity and the End of Science | 13 |
| 2.6 Let's Test Some Random Inputs! Feature Importance and Explainability | 13 |
| 2.7 The Universal Machine Learning Workflow | 13 |
| 3 Decision Making, Uncertainty and Chaos | 14 |
| 3.1 Concept Drift | 14 |
| 3.2 Theories of Creativity | 14 |
| 3.3 From Spaghetti Code to Lasagna Neuron Layers | 14 |
| 3.4 Garbage In, Garbage Out | 14 |
| 3.5 Garbage In, New Perspective Out? | 14 |
| 3.6 The Impossibility of Fairness | 14 |
| 3.7 What Are We Predicting Again? | 15 |
| 3.8 The Perverse Incentives of Data Scientists: Job Security by Obscurity | 15 |
| 3.9 Humans Love Computers | 15 |
| 4 Classification and Profiling: Studies in AdTech and Policing | 16 |
| 4.1 Everything is Clasification | 16 |
| 4.2 Classification in Reverse; Generating the Stereotype | 16 |
| 4.3 Code Your Own Classifier in 5 Minutes! | 16 |
| 4.4 The End of Nuance | 16 |
| 4.5 If You Were Unable To See A Doctor, is it OK? | 16 |
| 4.6 Lazy Thinking | 16 |
| 4.7 Data Where There Is None | 16 |
| 5 Self-Driving With Statistics | 17 |
| 5.1 Trolley Problems | 17 |
| 5.2 The Third Rail | 17 |
| 5.3 Purple Lights and Changes In Fashion | 17 |
| 5.4 Multicollinearity (Reprise) | 17 |
| 5.5 See You In Court, Asshole! | 17 |

| | | |
|----------|---|-----------|
| 6 | Generating Art: Avante-Garde or Derivative? | 18 |
| 6.1 | Predictive Keyboards | 18 |
| 6.2 | GPT On A Napkin | 18 |
| 6.3 | Compress The World’s Achievements Into One Database | 18 |
| 6.4 | Upscaling What Is Lost | 18 |
| 6.5 | Who Owns This Stuff Anyway? | 18 |
| 6.6 | Use Critical Thinking to Become A Critic | 19 |
| 7 | Revolutionary for Whom? | 20 |
| 7.1 | Self-Driving Horses | 20 |
| 7.2 | The Battle of the Assistants | 20 |
| 7.3 | Employees That Are Better Than You | 20 |
| 7.4 | Who is Helped the Most? | 20 |
| 7.5 | Who is Hurt the Most? | 20 |
| 7.6 | How to Respond | 20 |
| 7.7 | This Book is a Case Study | 20 |
| 8 | Unplugging Skynet | 21 |
| 8.1 | AI and Human Safety | 21 |
| 8.2 | Useful Incompatability | 21 |
| 8.3 | Checks and Balances | 21 |
| 8.4 | When You Can’t Tell The Difference | 21 |
| 8.5 | Sucker Traps | 21 |
| 8.6 | Dead Inside | 21 |
| 9 | Errors and Omissions | 22 |
| | Bibliography | 23 |

History: The End of Good Old-Fashioned Artificial Intelligence

1

"Programming will be obsolete. I believe the conventional idea of "writing a program" is headed for extinction, and indeed, for all but very specialized applications, most software, as we know it, will be replaced by AI systems that are trained rather than programmed. In situations where one needs a "simple" program (after all, not everything should require a model of hundreds of billions of parameters running on a cluster of GPUs), those programs will, themselves, be generated by an AI rather than coded by hand." Matt Welsh, 2023 [2]

1.1 The AI Textbook in 1997

Dr. Elaine Rich's textbook on Artificial Intelligence, published in the 1980s, was a groundbreaking work that helped to establish many of the foundational concepts and techniques in the field of AI. However, the rapid advancements in AI over the past few decades have led to many of the chapters in this textbook becoming obsolete.

One of the main reasons for this is the prevalence of deep learning, big data, and large-scale statistical models in modern AI. These techniques have largely replaced the symbolic, rule-based approach to AI that was emphasized in the textbook, making many of the chapters on knowledge representation and expert systems less relevant.

Additionally, the explosion of data and the availability of powerful computing resources have made it possible to apply machine learning techniques at a scale that was previously unimaginable. This has led to the development of highly effective machine learning models that can handle complex tasks such as image and speech recognition with a high degree of accuracy, making many of the chapters on simpler machine learning techniques such as decision trees¹ and linear regression less relevant. [3]²

We'll discuss this history and a few examples from the "early days" of AI to help us understand where we are headed. We'll start with machine translation, then discuss chess and finally neural networks, which will be the focus of the rest of this book.

1.2 Does AI Need to Know Grammar to Translate?

Noam Chomsky is a linguist and philosopher who has made significant contributions to the field of linguistics with his theory of universal grammar. Chomsky believes that all human languages share a common underlying structure, and that this structure is innate to humans. He proposes that this innate structure is the result of a "language acquisition device" present in the human brain, which allows us to learn and produce language. Chomsky

| | |
|---|---|
| 1.1 The AI Textbook in 1997 . . . | 1 |
| 1.2 Does AI Need to Know Grammar to Translate? | 1 |
| 1.3 Explicit Rules and Codified Human Knowledge | 2 |
| 1.4 IBM Tries Every Possible Chess Move | 4 |
| 1.5 Statistical Analysis of Hand-writing is the Way of the Future | 4 |
| 1.6 Less Programmer Intelligence and more Data Intelligence | 5 |
| 1.7 From Explicit Rules to a Black Box, and Beyond | 5 |
| 1.8 Key Takeaways | 6 |

1: Although mathematically, [Neural Networks are Decision Trees](#)

[3]: Rich et al. (2009), *Artificial Intelligence*

2: the book is now in its third edition and unlikely to be updated as Dr. Rich as retired [utexas.edu](#)

also argues that the structure of language is largely independent of its content, and that the ability to produce and understand language is a fundamental aspect of human nature. His theory has been influential in the field of linguistics and has sparked much debate and research on the nature of language and its relationship to the human mind.

For English speakers or anyone who has learned English as a second language you'll have many examples of special cases, irregular verbs, bad english and former street slang that became good and proper over time. For programmers this is a nightmare, how can we codify human knowledge in a timely fashion? If we tried to write the rules of the english language in code (which many have tried to do) the rules themselves might change before we were finished writing them.

Explicitly translating languages through code is a difficult task because it requires a thorough understanding of the grammar, vocabulary, and syntax of both languages, as well as the nuances and subtleties of their respective cultures³. Simply coding rules for how to translate words or phrases from one language to another is not sufficient, as there are often multiple valid translations for a given phrase depending on the context in which it is used.

A more effective approach to translation is to use statistical techniques that rely on a large corpus of translated data, such as Canadian laws⁴. This type of data-driven approach involves training a machine learning model on a large dataset of translations, allowing it to learn the patterns and relationships between the languages. The model can then use this knowledge to make educated translations of new phrases or sentences, taking into account the context in which they are used.

While this approach is not perfect, it has proven to be highly effective in machine translation and can produce accurate translations even for languages that are very different from each other. The use of a large dataset of translations also allows the model to learn from the mistakes and variations present in real-world translations, further improving its accuracy.

1.3 Explicit Rules and Codified Human Knowledge

When we "teach" a computer to perform a task by explicitly writing down all of the rules of that task, we are really codifying human understanding.⁵ When we codify human understanding we write down every rule that we know explicitly. For small tasks we can do this with 100 percent accuracy, and only minor headache on the part of the software developer.

For example, let's write a boring function to tell you the number of days for a given month.

3: For programmers this is a nightmare, how can we codify human knowledge in a timely fashion? If we tried to write the rules of the English language in code (which many have tried to do) the rules themselves might change before we were finished writing them.

4: They're in French AND English, which is useful data that we can use to correlate phrases and transform English to French and vice-versa.

5: Programming this way makes some software development totally boring, I almost switched my major in college to math after considering what a life would look like manually writing rules for handling "edge cases" for the rest of my natural life.


```
def days_in_month(year, month):
    if month in [1, 3, 5, 7, 8, 10, 12]:
        return 31
    elif month in [4, 6, 9, 11]:
        return 30
    elif month == 2:
        if (year % 4 == 0 and year % 100 != 0) or year % 400 == 0:
            return 29
        else:
            return 28
    else:
        return "Invalid month"
```

Writing code can be a tedious and repetitive task, especially when it comes to debugging and testing. It can be especially frustrating when you're working on a large project and you're trying to track down a specific bug that's causing the program to crash. Testing code can also be boring, as it often involves running the same tests over and over again to ensure that the code is working correctly.

Additionally, writing code can be boring because it requires a lot of concentration and focus. It can be easy to get lost in the details and lose track of time, especially if you're working on a complex problem. It can also be challenging to come up with creative solutions to problems, and it can be frustrating when your code doesn't work as expected.

While writing and testing code can be rewarding and fulfilling, it can also be a tedious and boring process. It requires a lot of patience, persistence, and attention to detail, and it can be easy to get frustrated and lose motivation. However, with practice and perseverance, it is possible to overcome these challenges and find enjoyment in the process of writing and testing code.

AI has traditionally operated by explicitly codifying human knowledge into machine-readable formats by doing the boring job of coding. This approach, which I'm calling "codified human knowledge" relies on humans to carefully structure and organize information in a way that can be understood by the AI system. The AI system then uses this structured knowledge to make decisions and perform tasks.⁶

However, recent advances in AI have largely ignored the knowledge representation problem and instead have focused on using statistical techniques and neural networks to automatically learn patterns and relationships in data. This approach, known as "deep learning," involves training large neural networks on vast amounts of data, allowing the AI system to make educated classifications and transformations of data without explicit human guidance.

Deep learning has proven to be highly effective in a variety of applications, such as image and speech recognition, and has contributed to the rapid progress we have seen in AI in recent years. However, the reliance on large amounts of data and the lack of transparency in these models can make it difficult to understand how they are making decisions, which can be a concern in certain applications (hence the title of this book).



Figure 1.1: "a frustrated programmer writing boring rules on his computer" made with Stable Diffusion 2.1

6: Some smart people think that AI spells the "End Of Programming", and I think the headline is clickbait but the general idea that programming is changing along with advances in AI is true. We are all data scientists now!

1.4 IBM Tries Every Possible Chess Move

Deep Blue was a revolutionary computer developed by IBM that was specifically designed to play chess at the highest level. It was programmed with a vast database of chess knowledge and was able to analyze millions of positions per second.

Garry Kasparov was the reigning world chess champion at the time, and he was considered to be one of the greatest players in history. He was beaten by Deep Blue, which used rules based GFOAI (Good Old Fashioned AI) to essentially calculate every possible move and project that move to the end of the game, then choose the best position by brute force.⁷ Despite Kasparov's best efforts, he was no match for Deep Blue's computational power. In the end, Deep Blue emerged victorious, defeating Kasparov in a historic match that changed the world of chess forever.

Deep Blue was a turning point in the development of AI, but Deep Blue's methods (namely calculating every possible outcome of a Chess game to determine the best move) was not suitable for many of the world's problems. It turns out that Chess is fun, but the world is not like chess.⁸ The "real"⁹ future of AI was being developed elsewhere, using statistics and a toy model of the brain to solve a very practical problem for banks.

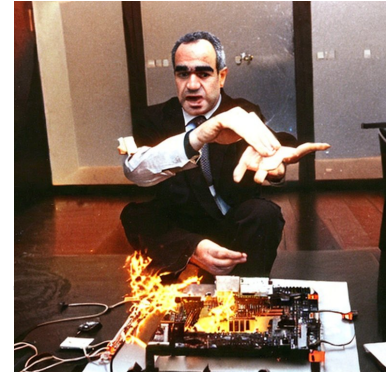


Figure 1.2: "Garry Kasparov setting a computer on fire" made with Stable Diffusion 2.1

8: if you would like to read an example of the simplest chess engine that I could imagine that is written in a similar "codified" way as Deep Blue check out [sunfish](#).

9: We might go back, and try again to more explicitly code everything up, and in some cases we still need to, but from the author's perspective, we live in a deep learning / neural network world.

1.5 Statistical Analysis of Handwriting is the Way of the Future

It was the early 1990s and Yann LeCun was a researcher at Bell Labs in New Jersey. At the time, the process of reading and processing checks was a tedious and time-consuming task that was done manually by bank employees. LeCun saw the potential for using artificial intelligence to automate this process, and he began experimenting with using convolutional neural networks (CNNs) to recognize patterns in images of checks.

At the time, CNNs were a relatively new type of neural network that had been developed in the 1980s for image recognition tasks. They were inspired by the structure of the human visual system, and were able to process images in a way that was similar to how the human brain does.

LeCun's work was groundbreaking, and he was able to achieve impressive results using CNNs to process checks. By 1993, he had developed a system that was able to read and process checks with a high degree of accuracy, significantly reducing the amount of time and effort that was required to process checks manually.¹⁰

LeCun's work on using CNNs for check processing was a major milestone in the field of artificial intelligence, and it laid the foundation for the development of many other applications of CNNs in the years that followed. Today, CNNs are widely used in a variety of applications, including facial recognition, image classification, and natural language processing.¹¹

10: CNN digit OCR models are frequently featured in beginner training tutorials for deep learning libraries like PyTorch and Tensorflow, check one out [on Github](#).

11: check out Yann LeCun demonstrating a convolutional neural network in 1993 at [youtube.com](#).

1.6 Less Programmer Intelligence and more Data Intelligence

I think it's useful to separate the knowledge in the AI problem-space into two groups. The data and the programmer together make the programs that we use every day, and for the rest of this book I'll try and separate the discussion of the smarts of each to help us better understand the world.
12

Early AI relied heavily on a human programmer to design, write, and debug computer programs. Good programmers needed domain expertise, problem-solving skills, logical thinking, and the ability to learn and adapt to new programming languages and technologies.

We are now in the age of big data, and everyone knows that "data is gold". Statistical AI methods that are now most prevalent rely on extracting meaningful insights and knowledge from large datasets. This involves using statistical and analytical methods to discover patterns and trends in data, and using this information to inform business decisions or solve problems.

Throughout this book I'll discuss the interaction between programmer and data, and what can go wrong. Working with big data and statistics at a large scale has given AI tremendous ability, but has made understanding and testing models infinitely more difficult. It is your authors belief that understanding the nuance of this interaction between programmer and data is essential to understanding modern AI.

1.7 From Explicit Rules to a Black Box, and Beyond

Artificial intelligence (AI) has come a long way since its inception, and the way that it makes decisions has changed significantly over time. In the early days of AI, explicit rules were used to tell the AI system what to do in certain situations. These rules were often written by humans and encoded into the system, and the AI would follow them to make decisions.

However, with the advent of deep learning, we have started to rely on a statistical understanding of the truth for AI to make decisions. Deep learning is a type of machine learning that involves training artificial neural networks on large datasets. These neural networks are able to learn patterns and relationships in the data, and can use this knowledge to make decisions.

The use of deep learning has led to the development of powerful AI that is able to perform tasks that were previously thought to be impossible for a machine to handle. For example, deep learning has led to the development of AI systems that are able to recognize faces, translate languages, and even beat humans at complex games like chess and Go.



Figure 1.3: "a group of computer programmers striking outside of Microsoft's offices with placards saying 'rule-based programming is boring'" made with Dall-E 2

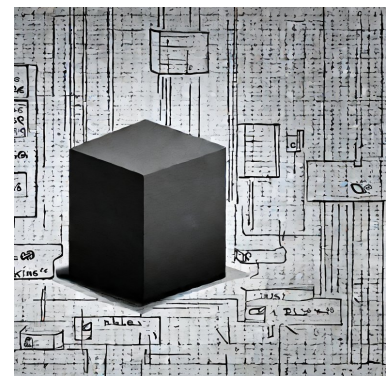


Figure 1.4: "from explicit rules, to a black box and beyond" made with Stable Diffusion 2.1

While deep learning has led to significant advances in AI, it has also made it harder to debug and understand how the AI system is making its decisions. With explicit rules, it was relatively easy to understand why the AI made a particular decision. However, with deep learning, it is often difficult to understand exactly how the AI arrived at its decision. This can make it challenging to troubleshoot problems with the AI system and to ensure that it is making decisions that are fair and unbiased.

AI has come a long way since its early days, and the way that it makes decisions has changed significantly over time. While explicit rules were once used to tell the AI what to do, we now rely on a statistical understanding of the truth for AI to make decisions. This has led to the development of powerful AI that is able to perform a wide range of tasks, but it has also made it harder to debug and understand how the AI is making its decisions.¹³

1.8 Key Takeaways

- ▶ **AI is a misleading term**, we should instead talk about rules-based programming (GOFAI) and deep learning so we don't confuse ourselves, our partners and our users.¹⁴
- ▶ **Good Old-Fashioned AI (rules-based AI) is hard to create and maintain.** We used to use it for chess engines (like Deep Blue) and translation, but now programmers favor using statistical machine learning techniques.
- ▶ Good Old-Fashioned AI is not well suited to many problems, like machine translation and handwriting detection.
- ▶ Modern Deep Learning techniques use data to train models instead of humans explicitly writing rules, and the **deep learning models are often as good as the data they are trained with.**¹⁵

13: From here on out I'll try and use "GOFAI" (Good Old-Fashioned Artificial Intelligence) to describe the rules-based approach, and use "Deep Learning" or "Machine Learning" to talk about modern neural network and statistics-based techniques

14: Avoid the imprecise words "Algorithms" and "AI" and instead consider the more precise "rules-based AI" AKA "GOFAI" to describe situations where programmers explicitly write rules that they design and "deep learning" or "machine learning" where programmers create models using a dataset and let the machine figure out the rules via a neural network.

15: More *intelligent* data and maybe less intelligent programmers, or maybe programmers who are better trained in statistics and complex systems theory instead of "classical" computer science.

The Regression Theory of Everything

2

"AI Scientists disagree as to whether these language networks possess true knowledge or are just mimicking humans by remembering the statistics of millions of words. I don't believe any kind of deep learning network will achieve the goal of AGI [Artificial General Intelligence] if the network doesn't model the world the way the brain does. Deep learning networks work well, but not because they solved the knowledge representation problem. They work well because they avoided it completely, relying on statistics and lots of data instead. How deep learning networks work is clever, their performance impressive, and they are commercially valuable. I am only pointing out that they don't possess knowledge and, therefore, are not on the path to having the ability of a five-year-old child." Jeff Hawkins, 2022 [4]

2.1 Let's Avoid Knowledge Representation!

The knowledge representation problem in AI is the challenge of how to formally represent knowledge in a way that a computer can understand and reason about. This typically involves creating a set of symbols, rules, and structures that can be used to represent concepts, relationships, and other types of information. The goal is to create a representation that is both expressive enough to capture all relevant aspects of the domain, and computationally tractable enough to allow for efficient reasoning and inference. There are many different approaches to knowledge representation, including logic-based, semantic networks, frames, and ontologies, each with their own strengths and weaknesses.

Deep learning techniques handle knowledge representation differently than traditional symbolic AI methods. Unlike symbolic AI, which relies on explicit and hand-coded representations of knowledge, deep learning techniques learn to represent knowledge implicitly through the use of neural networks.

In deep learning, knowledge is represented in the form of the weights of the neural network. These weights are learned through training on a large dataset and they capture the underlying relationships and patterns in the data. The neural network can then use these learned weights to make predictions, classifications or generate new data.

Deep learning models can handle large and complex datasets, and can automatically extract features from the data without the need for manual feature engineering. This makes them particularly well-suited for tasks such as image and speech recognition, natural language processing, and other areas where large amounts of data are available. However, they are not as good at explicating how they arrived at a decision, which can be a disadvantage.

| | |
|--|----|
| 2.1 Let's Avoid Knowledge Representation! | 7 |
| 2.2 A Simple Neural Network is also a Linear Regression | 8 |
| 2.3 Dummy Variables for Dummies (Wonkish) | 8 |
| 2.4 Try That Again With 33,640,010 Parameters | 10 |
| 2.5 Multicollinearity and the End of Science | 13 |
| 2.6 Let's Test Some Random Inputs! Feature Importance and Explainability | 13 |
| 2.7 The Universal Machine Learning Workflow | 13 |



Figure 2.1: "representing knowledge to a computer" by Stable Diffusion 2.1

In summary, deep learning techniques handle knowledge representation by learning the underlying patterns and relationships in the data through the use of neural networks, which can then be used for prediction, classification, and generation tasks.

2.2 A Simple Neural Network is also a Linear Regression

A neural network can be mathematically equivalent to a regression or a decision tree under certain conditions.

A neural network is a machine learning model composed of layers of interconnected artificial neurons, which are designed to process and analyze data. They can be used for a wide range of tasks, such as image and speech recognition, natural language processing, and prediction.

A regression is a statistical method used to predict a continuous variable based on one or more input features. A linear regression, for example, is a simple neural network with one input layer, one output layer and no hidden layers. In this case, the weights of the network are the coefficients of the linear equation and the network is equivalent to a linear regression model.

A decision tree is a tree-based model used for classification and prediction tasks. It consists of a series of if-then rules that are used to make decisions based on the input data. A neural network with one input layer, one output layer and one hidden layer with the ReLU activation¹ function is equivalent to a decision tree. This is because the ReLU activation function allows the network to implement a piecewise linear function which can represent the decision boundaries of a decision tree.

In summary, under certain conditions, a neural network can be mathematically equivalent to a linear regression or a decision tree. These conditions include having one input and one output layers, and having a specific activation function in the case of a decision tree.[5]

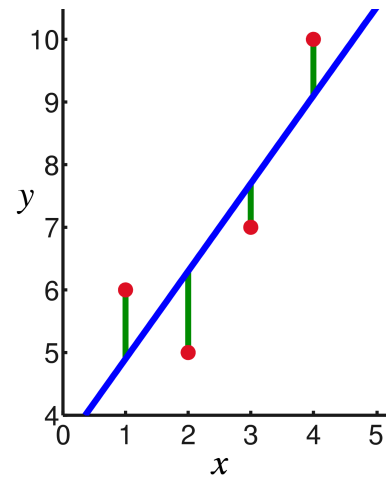


Figure 2.2: A simple linear regression, the red points are the training data, and the blue line is the regression line.

1: Neurons in a neural network can have different **activation functions**, if you don't know what it is and don't want to read about it in wikipedia, that's OK.

[5]: Aytekin (2022), *Neural Networks are Decision Trees*

2.3 Dummy Variables for Dummies (Wonkish)

Chapter Summary: It's all numbers, man. Machine learning techniques require that we turn everything (images, text, sound) into numbers and shove them into the model in the same way we use dummy variables in a simple regression. If you are satisfied with this, please skip this section. If you would like to learn a bit about the details and see some code examples, please keep reading. This section is necessarily technical, but should be approachable for anyone who has taken a college statistics class.²

Dummy variables are used in regression analysis to include categorical variables in a model. Categorical variables are variables that take on a finite number of distinct values, such as "red", "green", "blue" or "yes", "no". Since

2: Thanks to Paul Krugman for popularizing (to me at least) the *wonkish* classifier, I just mean it's a little nerdy. But it's important.

these variables cannot be directly included in a regression model, as they are not numerical, they need to be transformed into numerical variables.

The process of creating dummy variables is also known as one-hot encoding. It involves creating a new binary variable for each category of the original variable. For example, if you have a categorical variable "color" with three categories: "red", "green", "blue", you would create three binary variables: "color_red", "color_green", "color_blue". Each binary variable would take a value of 1 if the original variable is equal to the category, and 0 otherwise.

When using dummy variables in a regression, it is important to remember to include only $n-1$ binary variables, where n is the number of categories in the original variable. This is because including all n binary variables would result in perfect multicollinearity, which is when two or more independent variables are perfectly correlated. One of the binary variables can be dropped to avoid this problem.

Dummy variables are used in regression analysis to include categorical variables in a model. The process of creating dummy variables involves creating a new binary variable for each category of the original variable and one-hot encoding it. It is important to remember to include only $n-1$ binary variables, to avoid perfect multicollinearity.

The creation of dummy variables in a regression is analogous to preprocessing image, text and other data for a neural network for deep learning. This preprocessing is important as it ensures that the data is in a format that can be easily understood and processed by the network. The preprocessing steps for numbers, text, and images are slightly different.

For numbers:

- Normalization: It is common to normalize the input data by scaling it to have a mean of 0 and a standard deviation of 1. This helps to ensure that all input features have similar scales and prevents any one feature from dominating the network's computations.
- Imputation: Handling missing data is important, as it can negatively impact the model's performance. Common imputation techniques include replacing missing values with the mean, median, or mode of the feature.

For text:

- Tokenization: Text data must first be converted into a numerical format that can be understood by the network. This is typically done by tokenizing the text into individual words or n -grams and then encoding them as integers or real-valued vectors. A one-hot encoding exactly like the dummy variable method used in regression is also frequently used.^{3 4}
- Stop-words removal: The most common words in any language like "a", "an", "the", etc. that do not contain much meaning are called stop-words, they are often removed to reduce the dimensionality of the data.

Listing 2.1: Mapping text to numbers.

```
'movies': 99,
'after': 100,
'think': 101,
'characters': 102,
'watch': 103,
'two': 104,
'films': 105,
'character': 106,
'seen': 107,
'many': 108,
'being': 109
```

3: Sometimes text is just mapped to a number! Shocking, but it works. [Read more about word embeddings in the TensorFlow official tutorials.](#)

4: GPT-3 uses byte-level Byte Pair Encoding (BPE) tokenization and has a vocabulary size of 50,257.

- ▶ **Stemming/Lemmatization:** Words that have the same meaning can be stemmed or lemmatized to reduce the vocabulary size and increase the chances of generalization.
- ▶ **Vocabulary Size:** Each model must choose a vocabulary size or the maximum number of tokens that it will analyze. This may cause misspellings, slang or typos to be discarded in analysis.

For images:

- ▶ **Converting to RGB or Greyscale:** Each image is analyzed by its pixel color value, every point on an image will either have 3 color values (red, green, blue) or one single value (on a white/black scale) if the image is analyzed in greyscale.
- ▶ **Convolutions:** Pixel values are analyzed in groups that are defined by the model, since individual pixel values are only colors (or greyness) they must be combined together by the model to detect patterns like faces and stop signs. The method of convolution is defined by the model itself.
- ▶ **Resizing:** neural network can only accept images of a fixed size, so resizing the image to match the network's requirements is important.
- ▶ **Normalization:** It is common to normalize the pixel values to be in the range of 0-1 or -1 to 1. This will help the model converge faster.
- ▶ **Data Augmentation:** To increase the amount of data and prevent overfitting, common data augmentation techniques such as flipping, rotation, and cropping can be applied to the images.

In summary, preprocessing is an important step in training a neural network, as it ensures that the data is in a format that can be easily understood and processed by the network. The preprocessing steps for numbers, text, and images involve normalization, imputation, tokenization, stop-words removal, stemming/lemmatization, resizing and data augmentation.

2.4 Try That Again With 33,640,010 Parameters

In the first section of this chapter we introduced the idea that a simple neural network is mathematically equivalent to a regression. This is true and a useful way to think about neural networks and deep learning.⁵

In practice, neural networks frequently trained with millions of parameters. Here is an example of the trainable parameters of a simple image classifier. This example is a dense neural network to classify handwritten digits, and is not yet as sophisticated as the one used by Yann LeCun and company in the 1990s

In these next few examples, don't worry if you don't understand the layer types or know what batch normalization means. The point I would like to make is that neural networks are often created with millions of trainable parameters, once you agree with me regarding this point we will discuss the implications of this in more depth.

5:

$$y = Wx + b \quad (2.1)$$

There's your simple formula for a single-cell neural network and regression, in practice we'll change W , x and b to matrices and introduce nonlinear activation function f so,

$$y = f(Wx + b) \quad (2.2)$$

if you please. If equations scare you, don't worry about it for now.

| Layer (type) | Output Shape | Param # |
|---|--------------|---------|
| dense (Dense) | (None, 64) | 50240 |
| batch_normalization (Batch Normalization) | (None, 64) | 256 |
| dense_1 (Dense) | (None, 64) | 4160 |
| batch_normalization_1 (Batch Normalization) | (None, 64) | 256 |
| dense_2 (Dense) | (None, 64) | 4160 |
| batch_normalization_2 (Batch Normalization) | (None, 64) | 256 |
| dropout (Dropout) | (None, 64) | 0 |
| dense_3 (Dense) | (None, 10) | 650 |
| Total params: 59,978 | | |
| Trainable params: 59,594 | | |
| Non-trainable params: 384 | | |

59,594 parameters! That's not too bad for a simple neural network, but in practice the networks often get even bigger. Here is a *real* example that will make your brain a little hot.

| Layer (type) | Output Shape | Param # |
|---|---------------------|---------|
| conv2d (Conv2D) | (None, 28, 28, 64) | 640 |
| conv2d_1 (Conv2D) | (None, 28, 28, 64) | 36928 |
| max_pooling2d (MaxPooling2D) | (None, 14, 14, 64) | 0 |
| batch_normalization (Batch Normalization) | (None, 14, 14, 64) | 256 |
| conv2d_2 (Conv2D) | (None, 14, 14, 128) | 73856 |
| conv2d_3 (Conv2D) | (None, 14, 14, 128) | 147584 |
| max_pooling2d_1 (MaxPooling2D) | (None, 7, 7, 128) | 0 |
| batch_normalization_1 (Batch Normalization) | (None, 7, 7, 128) | 512 |
| conv2d_4 (Conv2D) | (None, 7, 7, 256) | 295168 |
| conv2d_5 (Conv2D) | (None, 7, 7, 256) | 590080 |
| conv2d_6 (Conv2D) | (None, 7, 7, 256) | 590080 |
| max_pooling2d_2 (MaxPooling2D) | (None, 3, 3, 256) | 0 |
| batch_normalization_2 (Batch Normalization) | (None, 3, 3, 256) | 1024 |

| | | |
|---|-------------------|----------|
| conv2d_7 (Conv2D) | (None, 3, 3, 512) | 1180160 |
| conv2d_8 (Conv2D) | (None, 3, 3, 512) | 2359808 |
| conv2d_9 (Conv2D) | (None, 3, 3, 512) | 2359808 |
| max_pooling2d_3 (MaxPooling2D) | (None, 2, 2, 512) | 0 |
| batch_normalization_3 (Batch Normalization) | (None, 2, 2, 512) | 2048 |
| conv2d_10 (Conv2D) | (None, 2, 2, 512) | 2359808 |
| conv2d_11 (Conv2D) | (None, 2, 2, 512) | 2359808 |
| conv2d_12 (Conv2D) | (None, 2, 2, 512) | 2359808 |
| max_pooling2d_4 (MaxPooling2D) | (None, 1, 1, 512) | 0 |
| batch_normalization_4 (Batch Normalization) | (None, 1, 1, 512) | 2048 |
| flatten (Flatten) | (None, 512) | 0 |
| dense (Dense) | (None, 4096) | 2101248 |
| dropout (Dropout) | (None, 4096) | 0 |
| dense_1 (Dense) | (None, 4096) | 16781312 |
| dropout_1 (Dropout) | (None, 4096) | 0 |
| dense_2 (Dense) | (None, 10) | 40970 |
| ===== | | |
| Total params: 33,642,954 | | |
| Trainable params: 33,640,010 | | |
| Non-trainable params: 2,944 | | |

When a neural network has millions of trainable parameters and deep layers of neurons, it can be difficult to explain to a human what each of those parameters represents or how they contribute to the overall function of the network. This is because the interactions between the different layers and neurons can be complex and non-linear, making it challenging to understand the specific role of each parameter. Additionally, many of the parameters are used to model complex interactions between the inputs and outputs, making it difficult to understand their specific function. Furthermore, in deep neural networks, the high number of layers can lead to high level of abstraction, meaning that the individual neurons and their weights have little interpretability.

Additionally, when a neural network has millions of interacting parameters, it can lead to mathematical chaos ⁶, which is a phenomenon where small changes in the initial conditions of the network can lead to vastly different outputs. This is because the interactions between the large number of

6: **Mathematical chaos** is a real thing! Mathematical chaos refers to the behavior of certain dynamic systems that are highly sensitive to initial conditions. This sensitivity leads to seemingly random and unpredictable behavior, even though the underlying equations governing the system are deterministic (meaning they are transparent and known to us).

parameters can create non-linear relationships that are sensitive to small changes. This can make it difficult to predict the behavior of the network, as small changes in the input or the parameters can lead to unexpected and seemingly random outputs. Additionally, the large number of parameters can make the network more prone to overfitting, where the network is able to memorize the training data but is not able to generalize to new data. This can further exacerbate the problem of chaotic behavior, as the network may produce unpredictable results on new, unseen data.

2.5 Multicollinearity and the End of Science

2.6 Let's Test Some Random Inputs! Feature Importance and Explainability

2.7 The Universal Machine Learning Workflow

Summarize and opine on The Universal Machine Learning Workflow [6]

[6]: Chollet (2022), *Deep learning with python, second edition*

Decision Making, Uncertainty and Chaos

3

"I hope for some sort of peace—but I fear that machines are ahead of morals by some centuries and when morals catch up there'll be no reason for any of it." Harry Truman, 1945 [7]

3.1 Concept Drift

3.2 Theories of Creativity

Is creativity combining existing things, or is it coming up with something new?

Does progress slow down because we heavily rely (more than usual) on the work of the past to generate future work?

3.3 From Spaghetti Code to Lasagna Neuron Layers

These layers are totally transparent, but you can't understand them because they're complicated :)

3.4 Garbage In, Garbage Out

You are essentially programming with data, so if your data sucks so will your prediction, you also really can't generalize, only correlate.

3.5 Garbage In, New Perspective Out?

What about cross-domain models, where maybe I train with a poetry dataset, and point my language model on nonfiction.... hmmm.

3.6 The Impossibility of Fairness

Representation, "fixing the training set" [8], or the Impossibility of Fairness from a model.

| | |
|---|----|
| 3.1 Concept Drift | 14 |
| 3.2 Theories of Creativity | 14 |
| 3.3 From Spaghetti Code to Lasagna Neuron Layers . . . | 14 |
| 3.4 Garbage In, Garbage Out . . | 14 |
| 3.5 Garbage In, New Perspective Out? | 14 |
| 3.6 The Impossibility of Fairness | 14 |
| 3.7 What Are We Predicting Again? | 15 |
| 3.8 The Perverse Incentives of Data Scientists: Job Security by Obscurity | 15 |
| 3.9 Humans Love Computers . . | 15 |

[8]: Christian (2020), *The Alignment Problem: Machine Learning and Human Values*

3.7 What Are We Predicting Again?

are you predicting the right thing? Are you really predicting how valuable the company is or just whether it'll be the next meme stock?

3.8 The Perverse Incentives of Data Scientists: Job Security by Obscurity

Investors want predictions, Data Scientists don't have good data, but want to keep their jobs. Bad science rolls downhill to the user, and takes a long time to snuff out.

3.9 Humans Love Computers

Working together seems like a good idea, but how. Talk about 2 percent model control and model uptake.

Also talk about Kasparov's tournament and Thinking for yourself in the age of AI. [9]

[9]: Mansharamani (2020), *Think for yourself: Restoring common sense in an age of experts and artificial intelligence*

Classification and Profiling: Studies in AdTech and Policing

4

4.1 Everything is Clasification

4.2 Classification in Reverse; Generating the Stereotype

4.3 Code Your Own Classifier in 5 Minutes!

Beginners tutorial

4.4 The End of Nuance

The unclassified?

4.5 If You Were Unable To See A Doctor, is it OK?

Increasing access of skin cancer detection.

4.6 Lazy Thinking

Online Advertising, Justice, Job Applications, Creditworthiness, Getting Insurance (Weapons of Math Destruction), Civic Life, /sideciteOneil2017 ; The Default Male, Invisible Women effects snow clearing schedules and drug discovery

4.7 Data Where There Is None

Talk about how generative tools can create data to be classified (like LAION).

| | |
|---|----|
| 4.1 Everything is Clasification | 16 |
| 4.2 Classification in Reverse; Generating the Stereotype | 16 |
| 4.3 Code Your Own Classifier in 5 Minutes! | 16 |
| 4.4 The End of Nuance | 16 |
| 4.5 If You Were Unable To See A Doctor, is it OK? | 16 |
| 4.6 Lazy Thinking | 16 |
| 4.7 Data Where There Is None | 16 |

5.1 Trolley Problems

5.2 The Third Rail

5.3 Purple Lights and Changes In Fashion

5.4 Multicollinearity (Reprise)

5.5 See You In Court, Asshole!

5.1 Trolley Problems 17

5.2 The Third Rail 17

5.3 Purple Lights and Changes
In Fashion 17

5.4 Multicollinearity (Reprise) . 17

5.5 See You In Court, Asshole! . 17

Generating Art: Avante-Garde or Derivative?

6

"(Traditional) search engines are databases, organized collections of data that can be stored, updated, and retrieved at will. (Traditional) search engines are indexes. a form of database, that connect things like keywords to URLs; they can be swiftly updated, incrementally, bit by bit (as when you update a phone number in the database that holds your contacts).

Large language models do something very different: they are not databases; they are text predictors, turbocharged versions of autocomplete. Fundamentally, what they learn are relationships between bits of text, like words, phrases, even whole sentences. And they use those relationships to predict other bits of text. And then they do something almost magical: they paraphrase those bits of texts, almost like a thesaurus but much much better. But as they do so, as they glom stuff together, something often gets lost in translation: which bits of text do and do not truly belong together." Gary Marcus, 2023 [10]

| | |
|---|----|
| 6.1 Predictive Keyboards | 18 |
| 6.2 GPT On A Napkin | 18 |
| 6.3 Compress The World's Achievements Into One Database | 18 |
| 6.4 Upscaling What Is Lost . . . | 18 |
| 6.5 Who Owns This Stuff Anyway? | 18 |
| 6.6 Use Critical Thinking to Become A Critic | 19 |

6.1 Predictive Keyboards

6.2 GPT On A Napkin

Discuss this ¹

1: [GPT On A Napkin](#)

6.3 Compress The World's Achievements Into One Database

Lossy lookup of data, see how close you get to creating famous artworks or wikipedia pages?

Talk about AI upscaling and AI as lossy compression. we stored the entire corpus of human knowledge, but AI retrieves it in a silly way.

6.4 Upscaling What Is Lost

How to leverage this stuff.

6.5 Who Owns This Stuff Anyway?

Discuss FSF and Copilot, lawsuits.

6.6 Use Critical Thinking to Become A Critic

Talk about ChatGPT, deterministic vs probabalistic and Thomas Hobbes
2

2: [AI Homework](#)

Revolutionary for Whom?

7

"The inhabitant of London could order by telephone, sipping his morning tea in bed, the various products of the whole earth – he could at the same time and by the same means adventure his wealth in the natural resources and new enterprise of any quarter of the world – he could secure forthwith, if he wished, cheap and comfortable means of transit to any country or climate without passport or other formality." John Maynard Keynes, 1920 [11]

| | |
|--|----|
| 7.1 Self-Driving Horses | 20 |
| 7.2 The Battle of the Assistants . | 20 |
| 7.3 Employees That Are Better Than You | 20 |
| 7.4 Who is Helped the Most? . . | 20 |
| 7.5 Who is Hurt the Most? . . . | 20 |
| 7.6 How to Respond | 20 |
| 7.7 This Book is a Case Study . . | 20 |

7.1 Self-Driving Horses

7.2 The Battle of the Assistants

Butler vs Indian Virtual Assistant vs Siri

7.3 Employees That Are Better Than You

Respond directly to Jon Krohn's TED talk about monkeys being dumber than us... what about construction equipment that's stronger than us physically, or racism/eugenics people that are dumber than us [12]

[12]: (2022), Jon Krohn

7.4 Who is Helped the Most?

7.5 Who is Hurt the Most?

7.6 How to Respond

7.7 This Book is a Case Study

"The second requirement of goal-misalignment risk is that an intelligent machine can commandeer the Earth's resources to pursue its goals, or in other ways prevent us from stopping it... We have similar concerns with humans. This is why no single person or entity can control the entire internet and why we require multiple people to launch a nuclear missile. Intelligent machines will not develop misaligned goals unless we go to great lengths to endow them with that ability. Even if they did, no machine can commandeer the world's resources unless we let it. We don't let a single human, or even a small number of humans, control the world's resources. We need to be similarly careful with machines." Jeff Hawkins, 2022 [4]

| | |
|---|----|
| 8.1 AI and Human Safety | 21 |
| 8.2 Useful Incompatability . . . | 21 |
| 8.3 Checks and Balances | 21 |
| 8.4 When You Can't Tell The Difference | 21 |
| 8.5 Sucker Traps | 21 |
| 8.6 Dead Inside | 21 |

8.1 AI and Human Safety

8.2 Useful Incompatability

It's a feature not a bug that no single computer can control all others, AKA Security by Obscurity

8.3 Checks and Balances

8.4 When You Can't Tell The Difference

Talk about Taleb's aphorisms "Another definition of modernity: conversations can be more and more completely reconstructed with clips from other conversations taking place at the same time on the planet.", "You are alive in inverse proportion to the density of cliches in your writing."

8.5 Sucker Traps

"The sucker's trap is when you focus on what you know and what others don't know, rather than the reverse."

8.6 Dead Inside

"If you know, in the morning, what your day looks like with any precision you are a little bit dead - the more precision the more dead you are."

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