SOMM: INTO THE MODEL

— AI FOR WINE PROFESSIONALS AND ENTHUSIASTS

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About the Author

Dottie Hu is an AI research scientist in New York City. Her research experience and interests lie in intersdisciplinary research bridging social sciences, computational linguistics, computer vision, and speech. She has published in top conferences and journals in natural language processing, computer vision, speech, and applied statistics including Association of Computational Linguistics (ACL), Empirical Methods in Natural Language Processing (EMNLP), Computer Vision and Pattern Recognition (CVPR), European Conference on Computer Vision (ECCV), International Conference on Computer Vision (ICCV), InterSpeech, and Annals of Applied Statistics (AoAS). She received her PhD from Cornell University in 2019.

She is also a wine professional with credentials including Certified Sommelier by The Court of Master Sommelier, Diploma in Wine with Merit by Wine & Spirits Education Trust, Certified Specialist of Wine by The Society of Wine Educators, and Certified Specialist of Spirits by The Society of Wine Educators. She is working towards the Master of Wine diploma by the Institude of Master of Wine.

SECTION 0

Introduction

Everything about wine appears intricate and complex, and mastering wine appears an ever daunting endeavor with the fast changing landscape of the worldwide wine industry, encompassing a wide range of subjects such as geology, geography, viticulture, viniculture, chemistry, law, marketing, operations, and more, in an almost multi-lingual and largely unstructured form.

From the meticulous handing by experienced sommerliers of delicate aged bottles that have been perhaps scrutinized for provenance at the dinner table, to the selection of distribution and marketing channels possibly subject to the arguably unnecessarily complex three-tier system, from different regimes at bottling that might cause or prevent wine faults in years to come, to numerous experiments done at different stages of *élevage* in the winery to finetune the final product, from intimate decisions on soil treatment, irrigation, vine training and trellising based on vintners' experience, ideals, and terrior, to the processes and experiments revolving around scions and rootstocks in the nursery, it might strike as without doubt that there is perhaps little space for artificial intelligence (AI) at its current state to take hold in the wine industry in the near future.

After all, the thought of ordering a bottle of wine with personal recommendations through a robot at a dinner table, or conversing with Google Home or Amazon Alexa about the intricacies that make Musigny more different than Bonnes Mares than Les Amoureuses, devoid of any human touch of hospitality, would easily make one squirm.

On the other hand, artificial intelligence has made breathtaking breakthroughs in multiple fields in the past decade, not only solving some of the world's most pressing and challenging puzzles, but also penetrating various aspects of our daily lives. AI is making it easier for people to do things every day, whether it's searching for photos of loved ones with a simple

query, breaking down language barriers with smart online translators, typing emails with automatic completion, or getting things done with the Google Assistant. AI also provides new ways of looking at existing problems, from rethinking healthcare to advancing scientific discovery. One particularly relevant research theme that is quickly emerging is AI for Social Good, which uses and advances artificial intelligence to address societal issues and improve the well-being of the world. In an excellent review article by the AI and Social Good Lab at Carnegie Mellon University summarized over one thousand relevant academic articles published in top computer science conferences in the following plots by application areas over time:

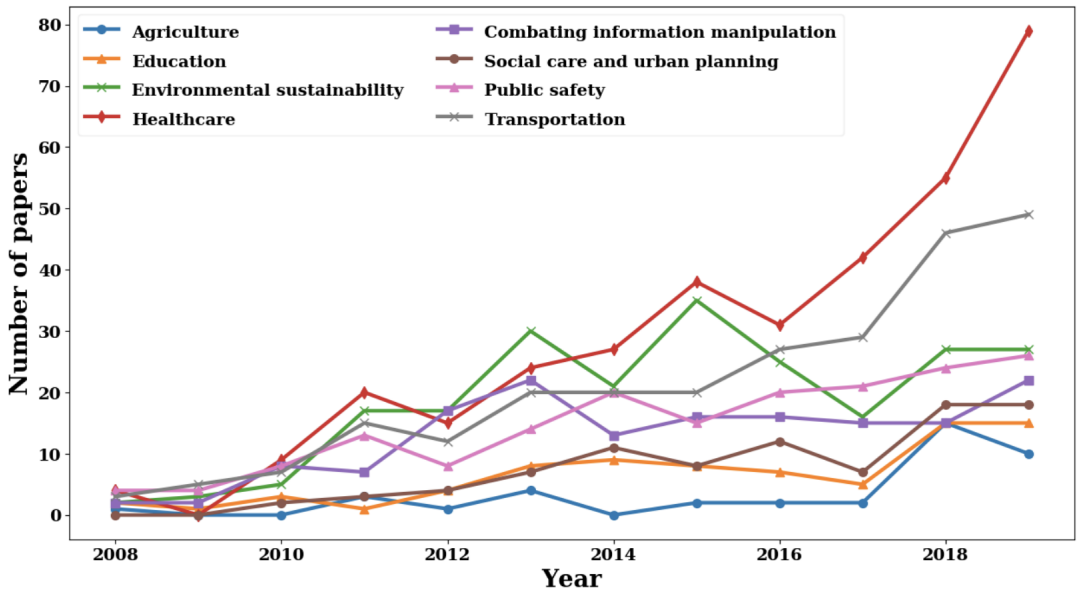


Figure 1: Evolution of AI for Social Good Application Domains [Shi et al., 2020].

With the steady (even exponential) growth of AI technology in various public domains, there is no reason why the wine industry, that overlaps with so many other industries in Figure 1 wouldn't benefit from AI technology. It is my strong conviction that various AI technologies can already resolve many issues of the wine industry in a surprisingly efficient manner, and I am going to show you how in this book in a fun and non-technical way that your parents would understand and hopefully agree.

Objectives of This Book

How could AI assist wine professionals in various aspects of the wine world, perhaps change the wine industry for the better, and ultimately enrich consumers' experience? I try to illustrate by

- examining the essential qualities and responsiblities of wine professionals or sommeliers through the lens of AI, and detailing how to use AI to help with relevant tasks;
- identifying components of the wine industry where AI could potentially improve upon wine professionals, or make their job easier and more efficient at the very least;

- solving challenging problems that have shaken the sommelier circles in recent years;
- laying out future plans to building an ultimate sommelier-in-the-loop AI system for the wine industry.

The Structure of This Book

Chapter by chapter, I will discuss wine-related topics and the challenges therein, followed by to what extent could AI be of help, and in what ways, with introductions to the relevant topics in AI. I try to include as many visualizations, and demos, as possible to make it fun. More *interactive* visualizations, technical versions of the AI parts (in the form of literature review in scientific papers from a previous version of this book), and other topics are available online at https://ai-somm.com.

This book can be read in at least three distinctive ways. First, each chapter provides a visualization that aggregates certain wine knowledge in a (hopefully) creative way. Second, every chapter addresses one of the wine-related challenges commonly faced by wine professionals and/or enthusiasts with a set of AI solutions, introduced in a nontechnical way alongside visualizations, sample results, and demos, when appropriate. Third, every chapter further the discussion, in subsections, of relevant AI methods with a self-contained and relatively non-technical review of method development and evolution over the past decade, while technical reviews are also made available online at https://ai-somm.com. Therefore, each chapter assumes in parallel two themes, one relevant to the wine industry, the other the AI industry. Yet both parts would be self-contained thus no previous knowledge is required to grasp the texts, except a curious mind and a playful heart. In addition, each chapter is in itself self-contained and can be read separately, therefore readers are welcome to read in whatever order you like.

Hopefully, this book makes a unique and novel addition to the wine literature, and the AI literature, while being broad enough in scope to be of use across the wine profession, and perhaps inspire AI applications in other fields as well. Because of the fast-evolving nature of the AI technology (and perhaps the wine industry too), I hope to continuously update the chapters with the newest methods and introduce new topics, possibly with a second edition, a third edition, and so on.

A Preview of Chapters

Chapter 1 discusses in-depth about what wine professionals and enthusiasts love (and hate): blind tasting. It has been an essential part of training for wine professionals. However, it does appears that everyone has his or her own unique marker or method, on top of the generally accepted so-called “deductive tasting“. I detail some of the many schools of thought about how to conduct deductive tasting, highlighting their major flaws and inconsistencies, while illustrating how this exact problem corresponds to some of the most classic machine learning methods, which in turn could be used to prevent pitfalls and identify the optimal strategy of deduction.

Chapter 2 gets into the weeds of the vast body of wine knowledge touching on various distinct yet intertwined subjects such as geology, geography, chemistry, viticulture, viniculture, economics, etc. A solid grasp of a large body of wine knowledge is fundamental to being a qualified wine professional, just as how knowledge graphs are fundamental to various AI models and their generalizability[1] and flexibility. We recount the important roles knowledge graphs have been playing in modern AI ecosystems, and illustrate with examples how knowledge graphs could be integrated to build question-answering systems like chatbox applications tailored to the wine industry.

Chapter 3 broaches the classic topic of food and wine pairing. Given the textual description of a dish and the identify of a bottle of wine, how could AI methods be used to help determine their compatibility? Given a random food image, how would AI models recommend a wine to pair with, with rationales? Furthermore, given a bottle wine, how could we generate a recipe for a dish that goes well with it, with personal preference customization? We will break down each of the scenarios, and explain AI solutions module by module.

Chapter 4 explores the colorful landscape of wine maps, by comparing various wine map collections and cartography projects. Map-making, or cartography, has long been a labor intensive and time-consuming process that requires extensive and in-depth knowledge of visual design, geography, perception, aesthetics, etc., on the part of cartographers or designers, despite the powerful modern softwares like Adobe Illustrator and ArcGIS that have partially eased the process. When it comes artisanal wine maps that are artistically stylized, however, manual hand-drawing appears inevitable. Could AI help automatically generate artistic maps with style and precision in no time? The answer is yes, yet not without challenges.

Chapter 5 describes the phenomena of flying winemakers, and globe-trotting wine professionals and enthusiasts, and introduces the wine equivalents of the fun game GeoGuesser: VineyardGuesser — given an image of a vineyard, guess where it is located in the world, and CellarGuesser — given an image of a cellar, guess which winery it is! Can you achieve more correct guesses than our AI Guesser? You might be surprised. We will discuss the ins and outs of image geolocalization and how it applies to vineyards and cellars.

Chapter 6 details the fascinating world of grape varieties. Which grape varieties in the world are similar in terms of fruit profile, or structure, or growing patterns? What are the varieties that share something in common with both Riesling and Viognier? To answer such questions and many more, with the help of some of the widely used methods in AI, we produce a comprehensive map of the world's thousands *vitis vinifera*, from which links and associations among grape varieties could be easily identified. Could AI help with grape variety identification in the vineyard with a single photo of the grape vine on the ground? The answers are indeed positive, with the help of fine-grained visual classification applications in computer vision.

Chapter 7 maps out the kaleidoscopic space of (craft) cocktails as a semantic network[2]. What makes a cocktail creative? There is a popular misconception that a great idea strikes from out of the blue, much like the apple that supposedly fell on Newton's head. In fact,

[1] The extent to which these models can be generalized to other domains.

[2] A network of interconnected concepts.

almost every idea, no matter how groundbreaking or innovative, depends closely on those that came before. We analyze the creativity of craft cocktails through the lens of semantic networks and network theory, and provide creative tools and insights for aspiring mixologists. Furthermore, with the help of recent advancement in text generation technologies, we demonstrate how to automatically generate creative cocktail recipes, given minimal inputs.

Chapter 8 examines some of the world's best curated wine lists and explores what makes a great wine list in a data-driven manner. We introduce AI methods particularly adapted to parse a wine list, provide a comprehensive evaluation of any given wine list, and ultimately, generate a wine list given certain constraints such as budget, restaurant theme, perceived creativity, target consumer segments, etc., envisioning the future of AI assistants to wine directors at Michelin-starred restaurants and rustic bistros alike.

Chapter 9 seeks to tease out the causal effects of *Terrior* vs. *Vignerons* on wine quality, as opposed to spurious correlation, by introducing the most classic methods in Econometrics[3] and Statistical Learning[4] of causal inference, as well as their modern renditions in AI research.

Chapter 10 touches on the good old problem of trust-building among supply chain partners in the wine industry. Unsurprisingly, this is by no means a problem unique to the wine industry, therefore we review research efforts and practical insights over the past decade or so on the topics of automatic deception detection, and information concealment detection in text and speech with practical demos as potential solutions to some issues in the wine industry.

Chapter 11 elaborates on the worldwide wine auction scene. What are the optimal strategies for the auctioneer and the customers, respectively? What are some pitfalls corresponding to different mechanism designs from the perspective of customers? How could we induce truth-telling and perhaps greater market efficiency with mechanism design of auctions? In this chapter, we delve deep into the classic game theory and mechanism design that prove wildly relevant in the modern world.

Societal biases could result in social inequity through prejudice (emotional bias), stereotypes (cognitive bias), and discrimination (behavioral bias). The wine industry is no exception. In **chapter 12**, we review how AI could augment or mitigate societal biases in various stages, pinpoint the major sources of algorithmic biases, and highlight the dangers of AI applications if such issues are not taken seriously.

Background Information

Before we start, let us clarify the meaning of artificial intelligence with some background information, as well as several closely related terms you will frequent in this book, and the AI community in general.

With the ever increasing amounts of data in digital form, the need for automated methods

[3]The subject of the application of statistical methods to economic data for meaningful interpretation of economic behaviors and activities.

[4]The sub-field of machine learning drawing from the fields of statistics and functional analysis.

for data analysis continues to grow. The goal of **machine learning (ML)** is to develop methods that can automatically detect patterns in data, and then to use the uncovered patterns to predict future data or other outcomes of interest. Machine learning is thus closely related to the fields of statistics and data mining, but differs slightly in terms of its emphasis and terminology.

Data mining deals with challenges particularly in the areas of data storage, organization and searching.

The learning problems that we consider can be roughly categorized as either supervised or unsupervised, with those in-between termed semi-supervised. In supervised learning, the goal is to predict the value of an outcome measure based on a number of input measures; in unsupervised learning, there is no outcome measure, and the goal is to describe the associations and patterns among a set of input measures. **Statistical learning** brings together many of the important new ideas in learning from data, and explain them in a statistical framework.

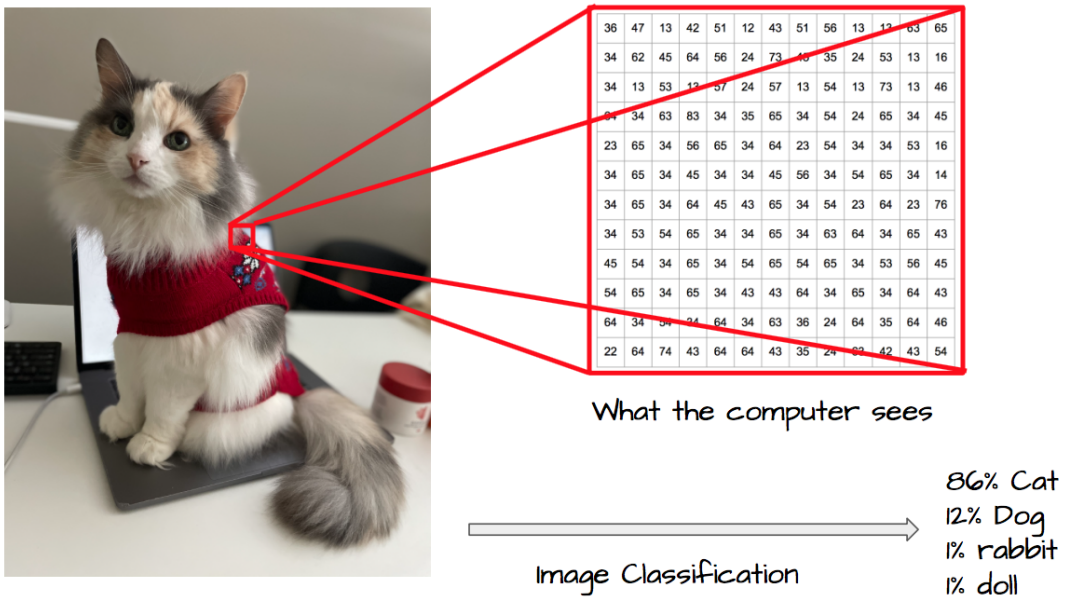
The desire of creating machines that think dates back to at least ancient times when the tales of giant bronze robot Talos, artificial woman Pandora and their creator god, Hephaestus, filled the imaginations of people in ancient Greece. When computers first came into being, people had wondered whether they might become intelligent. Today, **Artificial intelligence (AI)** as a field has come a long way with numerous practical applications and active research topics, from intelligent software for automating routine labor, to speed and language understanding, from image and video perception, to scientific diagnoses in medicine, and many more. In the early stages of AI, problems that are intellectually difficult for human beings but relatively straightforward for computers were quickly solved. These are the ones that can be described by a list of mathematical rules. The real challenge to AI remains those easy for humans to perform that are difficult to articulate — those we solve effortlessly and intuitively, such as recognizing faces in images, or recognizing spoken words in a speech. The solution to such tasks — natural for human but challenging for machines, is to allow computers to learn from experience, mostly in the form of data, and understand the world in terms of a web of concepts, the hierarchy of which allows the computers to learn complicated concepts by building them upon simpler ones, just like how humans learn. If we draw graphs of these learned concepts built on top of one another, these graphs are deep with many layers. Therefore, this approach to AI is termed **Deep learning**.

Natural language processing (NLP) is the use of human languages, such as English or Japanese, by a computer. Different than computer languages that were designed to allow efficient and unambiguous parsing, natural language processing commonly revolves around resolving ambiguous and informal descriptions, and includes applications such as question answering (covered in Section 2.2), text generation (covered in Section 3.2, Section 8.2, and Section 7.3), machine translation (touched on in Section 2.1), named entity recognition (touched on in Section 2) and many more.

Speech recognition aims to map an acoustic signal containing a spoken natural language utterance into the corresponding sequence of words intended by the speaker. The **automatic speech recognition (ASR)** task aims to identify an automatic function for that map-

ping, nowadays mostly based on *deep learning* methods. We will touch on some parts of it in Section 10.1.

Traditionally one of the most active research area for deep learning applications since vision is a task effortless for humans and animals but challenging for computers, **computer vision (CV)** is a very broad field consisting of a wide variety of methods of processing images resulting in an amazing diversity of applications, ranging from reproducing human visual abilities, for instance, recognizing faces, to creating new categories of visual abilities, such as recognizing sound waves from silent videos based on vibrations induced in objects visible therein. Many of the most popular standard benchmark tasks for *deep learning* methods are forms of *object recognition*, covered in Section 3, Section 6 and Section 5, as well as *optical character recognition*, covered in Section 4.4. Computer vision also overlaps with *computer graphics*, surfacing creative and efficient solutions to problems such as repairing defects in images, coloring black and white images, artistically stylize photos, and many more. We will discuss some of these in Section 4.



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