

AI and Machine Learning Are Becoming Brewers – (Really!)

A Look at Business Innovation & The Craft Brewing Industry

In this paper, we are going to discuss some important concepts that are currently impacting and will impact the future of the craft beer industry:

- 🏠 Brewing and patents
- 🏠 Innovation in the brewing industry
- 🏠 Emergence of Artificial Intelligence in brewing
- 🏠 Innovation strategies and brewing culture



When the brewing kettle is fired up, the grains mashed, the wort boiled, and the fermentation yeast added in an effort to create that wonderful elixir known as beer, brewers are drawing on the disciplines, equipment, and ingredients that in some cases go back thousands of years. One thing that has remained constant in all that time is the innovation brewers have put into the art and science of brewing beer.

Be it a new way to mill grain, creating a hybrid hops plant, mixing a new recipe, or creating unique artwork for a label, brewers are inventive and progressive with their craft, always searching, always perfecting.

In our modern times, the craft brewing industry has added a new element to consider: competition. In the USA, as of 2017 there were some 6,372 craft breweries, with the trend line increasing to more than 7,000 in 2018.¹ To put that in perspective, there are roughly only 7,000 Burger King fast food restaurants in the USA.²

Not only do brewers have to compete against other brewers' inventiveness, brewers also must consider the entire secondary brewery supply industry that has sprung up to support so many craft breweries. These companies are producing innovation at a rapid pace. While this is certainly a good thing, as it offers new tools for creativity and efficiency, it can also crowd inventive brewers (or suppliers) looking to gain an edge, as someone else beats them to a new idea.

Beyond the fine art of actually brewing beer, members of today's brewing industry must think about how they are going to compete with other brewers and suppliers on multiple levels, as mere competition numbers require it.

When we look at the patent literature, searching the terms "beer brewing," "craft beer," and "beer production," we pull back some 3,563 patents and applications covering the past eight years. These

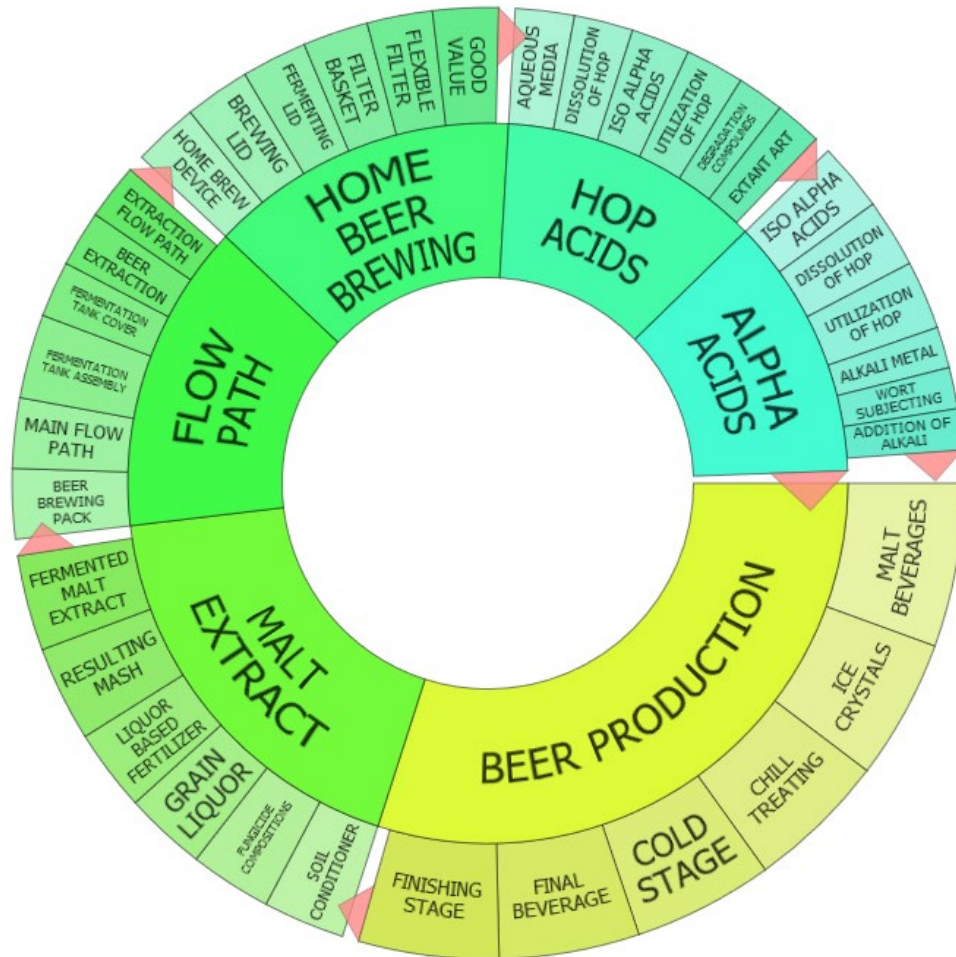
¹ "Number of Breweries", Brewers Association, Site Accessed Jan 2019 : <https://www.brewersassociation.org/statistics/number-of-breweries/>

² Wikipedia contributors. (2018, December 28). Burger King. In *Wikipedia, The Free Encyclopedia*. Retrieved 18:27, January 14, 2019, from https://en.wikipedia.org/w/index.php?title=Burger_King&oldid=875654382

numbers don't even begin to get into some of the more specific equipment used in brewing that don't necessarily have the word "beer" in their patent title or claims.

The following chart shows where people in the brewing industry are concentrating their innovation; as we can see, it covers a broad range of topics. From Malt Extracts to Hop Acids and Filter Baskets to Tank Covers, innovation in the brewing space is happening daily and innovators are protecting it.

FIG 1



This small section of the patent literature doesn't even take into consideration industries that supply the craft brewing sector; their equipment and techniques are more broadly applied to other industries as well (e.g., canning). When you add in those patents, the figures shoot up in the tens-of-thousands.

Enter Artificial Intelligence, Enter more competition

When we think about brewing, we often romanticize the practice. Back to basics, a noble profession, using fruit of the Earth to create a desired and loved product. One might ask where artificial intelligence (AI) would come in to such an endeavor?

Today, even many homebrewers use some sort of software such as *Beersmith* or *BeerTools* to help scale batches and keep track of the process. Craft breweries, even micro ones pumping out less than 3,000 barrels a year, generally have some form of Brewery Management Software. Software technology has already wormed its way into this ancient practice, but again, where does AI come in? One word: Recipes.



Applying the field of AI to recipe generation is just beginning to emerge, and while some questionable examples exist, like “blueberry and onion soup”, the positive results are showing that AI can take deeply complex aspects of different ingredients, analyze them, and offer up new ideas for humans to try. This is the concept behind AI software such as *Foodpairing*,³ a tool which finds and analyzes compatibility between different ingredients.

Recently, a project by MIT graduate students and postdoctoral researchers, “How To Generate (Almost) Anything,” used *textgrrnn*, an open source recurrent neural network that produces phrases from large text datasets.⁴ They used the tool against data from food blogs that cover pizza recipes and then teamed up with a pizza restaurant in Boston to make some of the suggestions. One of the results “shrimp, jam, and Italian sausage combo” was so good they put it on the menu!

Now imagine when you take a food item as complex as beer. Made from a vast array of hops, grains, adjuncts, yeast, and of course additives up and down the spectrum from pumpkin to oak chips, beer is one of the most complex beverages on the planet. It is an industry waiting for AI application. It’s already starting. InBev is using AI from barley production to supply chain.⁵ There’s even a company called IntelligentX Brewing Company that allows users to give feedback via a smartphone app to an AI agent about its beers. That AI then offers the brewmaster suggested tweaks to the recipe.

Going back to the patent literature we mentioned earlier, while our high-level study doesn’t specifically pull out AI patents related to brewing, if we do a cursory review of the data, we can see intellectual property that is nipping around the edges of this emerging area. Consider the following 2016 patent

³ The Science behind Foodpairing® Site accessed January 2019, <https://www.foodpairing.com/en/science-behind>

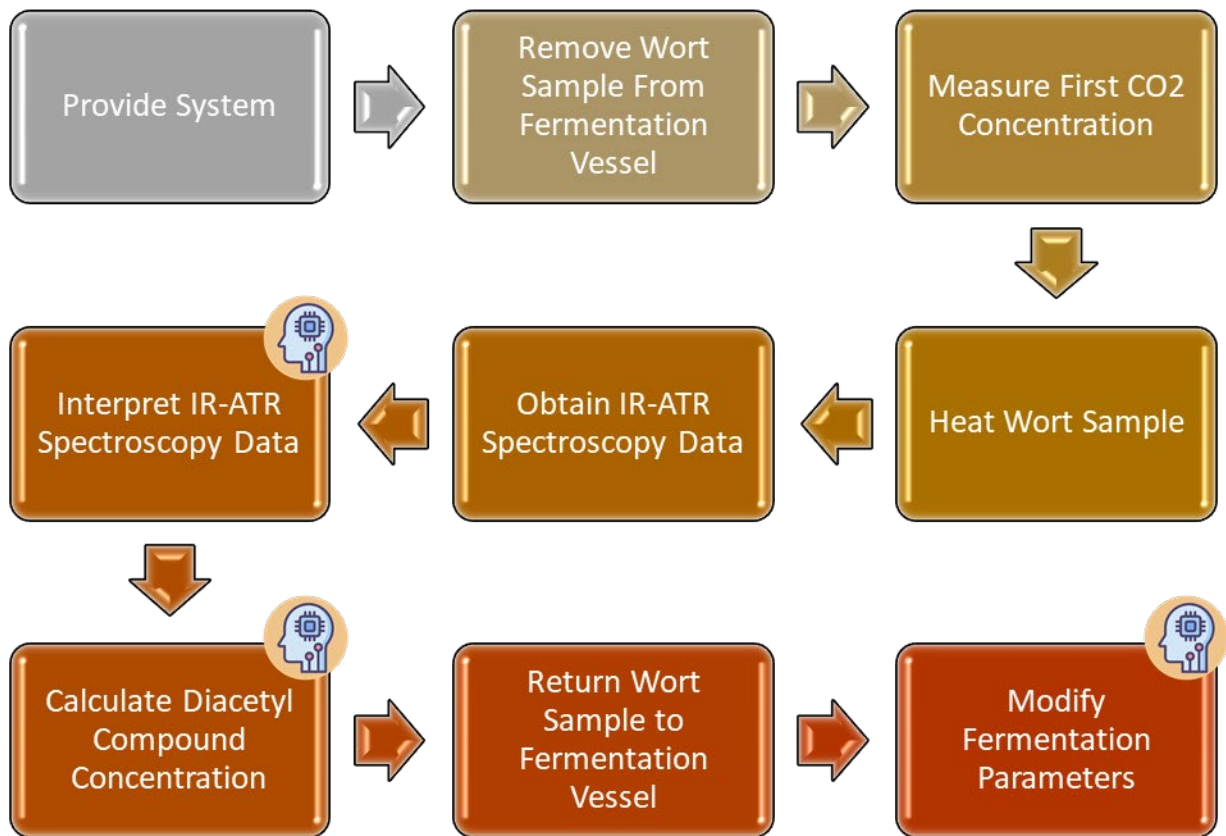
⁴ Kyle Wiggers, “MIT students use AI to cook up pizza recipes”, Venturebeat.com, September 10 2018 <https://venturebeat.com/2018/09/10/mit-students-use-ai-to-cook-up-pizza-recipes/>

⁵ “From seed to sip: How Anheuser-Busch InBev uses AI to drive growth”, December 5th 2018, Microsoft.com, Site Accessed January 2019, <https://news.microsoft.com/transform/from-seed-to-sip-how-anheuser-busch-inbev-uses-ai-to-drive-growth/>

application from the University of Northern Colorado, US2016369214A1 “In-Line Detection of Chemical Compounds in Beer.”⁶ The abstract indicates the following disclosed invention:

“Apparatus, methods, and systems for in-line detection of chemical compounds in beer are provided. In these apparatus, methods, and systems, a small sample of wort is removed from a fermentation vessel, heated, analyzed by infrared attenuated total reflectance (IR-ATR) spectroscopy, and returned to the fermentation vessel. The concentrations of one or more chemical compounds in the wort can be ascertained directly from IR-ATR spectroscopy data, or indirectly from applying an algorithm to the IR-ATR spectroscopy data based on known reaction kinetics and stoichiometry. The apparatus, methods, and systems do not destroy the wort sample or contaminate the fermenting wort and so can be employed continuously during fermentation, and are rapid, accurate, and inexpensive.”

The inventions process flow, as indicated in Figure 1 of the application, is as follows. For emphasis, I’ve added three “AI Icons” to show where artificial intelligence can or should play a part in the technique.



The barrier to applying AI to brewing (or just about any industry now) is *extremely* low. Honestly, a majority of the heavy lifting in this area has already been done. You don’t need a team of high skilled programmers banging out complicated algorithms and building convolutional neural networks for them to run on. There are already vast open source depositories of this information and the repositories get bigger and offer more targeted AI, Machine Learning, BPA, and other automation tools almost daily.

⁶ Mosher, Michael (2016) US Patent App No US2016369214A1 Retrieved from Patseer.com

My consulting company, ipCapital Group, Inc., has a database of more than 1,000 AI tools and resources that we can delve into in assisting us with AI consulting projects. While there was certainly sweat equity in compiling the database, there's nothing secretive about the sources; they are all discoverable through research on the internet. You can bet any number of these tools are being discovered by your competitors out there.

When such AI tools become widespread, it won't just be humans that brewers need to compete with to come up with their next blockbuster brew, it will be computers too.

[A Sharing Culture](#)

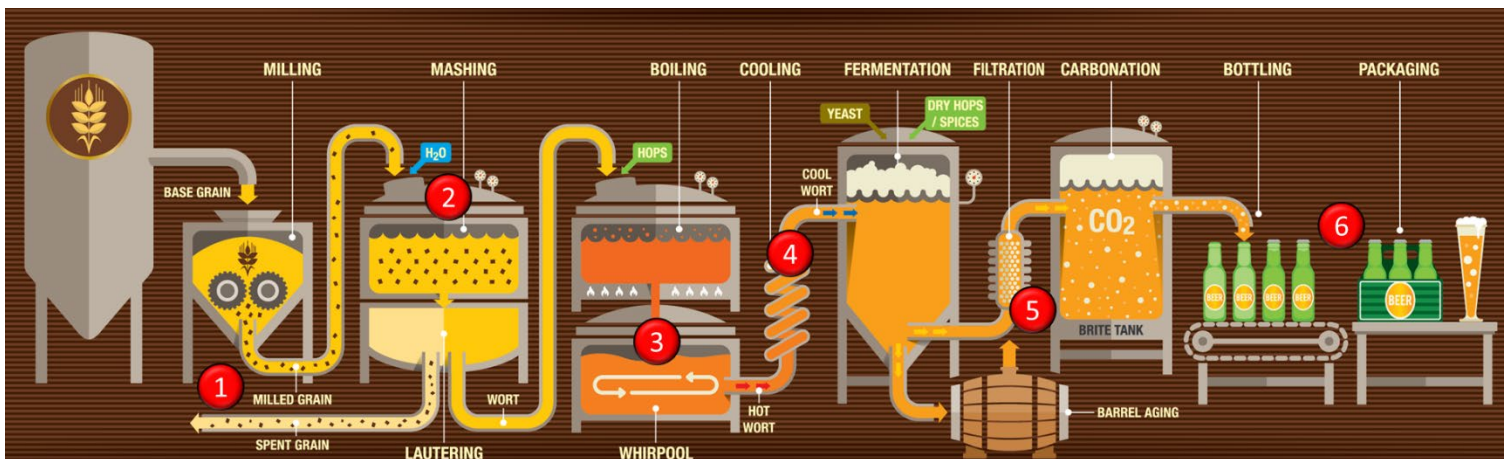
A note on innovation. Brewers are generally a convivial group of people. It's hard to be uptight around beer. As a brewer myself, I can't count the amount of times someone has lent me a kettle or some yeast, and I of course returned the favor when they were in need. Brewing is industry that often even sees competing breweries teaming up to make collaborative brews (*Class of 2017 New York City Pale Ale, anyone?*)

Yet, simply because brewers tend to be neighborly, it doesn't mean they don't need to guard their innovations. Most brewers certainly know about copyrights, and perhaps a patent might be a bridge too far for some of your ideas, but there are numerous ways one can be innovative, vigilant, and magnanimous. A well-regulated and document trade secret program is one possibility, another is through licensing. If you create something really unique, a process, an algorithm, or piece of machinery, you should consider patenting it. You need not charge anything to anyone to use these ideas under these IP structures, if you so choose, but you can still protect your intellectual property and control how an industry incorporates your ideas.

[The Brewing Process Enhanced](#)

We know innovation is happening. We see it in the patent literature, and we see it in marketplace. Where then, could these innovations be placed in your brewing operation?

The following graphic shows a typical brewing process and indicated over the process are suggested areas where innovation and AI can be instituted to create greater efficiencies or creativity. This is by no means an exhaustive example, just some highlights to show where there are ample opportunities to apply



emerging technology to the brewing process. I've added some of my own AI brainstorming to various parts of the process. I'm betting you can come up with some of your own right now as well!

1. Wastewater and spent grain disposal. - According to the Brewers Association, the average water-to-beer ratio for a brewery is around 7-to-1.⁷ As you know, this waste water has very high levels of biological oxygen demand (BOD), making it tough to treat. There is opportunity here though. Companies such as Cambrian Innovation in Watertown, MA are creating "energy neutral" ways to treat waste water. Average brewery wastewater can have up to 3kWh of energy per kilogram of BOD. You can use the energy in something you're currently throwing away to help the environment and fend off or at least comply with new government regulations specifically targeting breweries. *AI Suggestion: Plug in IntelliFlux, Augmented Process Recommendation & Industrial Control Optimization Tools (APRICOT) and get end-to-end decision automation for water treatment.*

And all that spent grain? Well, if you're not turning it in to a smorgasbord of delicious baked goods and creating a revenue stream from it, then you should at least be selling it as stock feed or using it as compost.⁸

2. Mashing & Pumping – Variable Speed Drives or VSDs take incoming power to your brewery and digitally recreate the three separate sine waves of electricity, allowing you to regulate the power flow up or down. Allowing you, for example, to control the speed of a three-phase pump motor. There can be significant energy savings using VSDs. The Romford Brewery in the United Kingdom installed a VSD and achieved a 45% reduction in motor power use.⁹ *AI Suggestion, Use AI to detect motor faults and adjust power appropriately to maintain torque.*

3. Wort Whirlpool - If you own a commercial brewery or are *heavily* into home brewing, you know there is a problem when you begin the whirlpool for your wort; volatile substances (primarily Dimethyl Sulphides) can begin to form and create off-flavors in your beer (think creamed corn, although some beer styles do shoot for this taste). A technique called "wort stripping," where you remove these volatiles, can be performed through numerous technological processes. From aerators to steamers, there is not only an innovation already out there, but plenty of room for additional invention. *AI Suggestion: Use a machine learning algorithm could adjust CO2 inputs and other scrubbing techniques, based on recipe parameters and monitoring of C₂H₆S compounds.*

4. Wort Cooling – What is one of *the* most water wasting, tedious events in the brewing process? Chilling of the wort! Rapid cooling equals better beer, and essentially, brewers have had three cooling options to choose from: Immersion chillers, counterflow chillers and plate chillers. But did you know fluid cooling is a problem larger than just cooling wort in the brewing process? There are several industries that have the need to cool a liquid down rapidly. Some of these methods used in other industries could be applied to brewing equipment. Ethylene glycol and water (EGW) and propylene glycol and water (PGW) solutions that recirculate the cooling glycols through electric chillers could revolutionize this portion of the brewing process.

⁷ Chastain, Cheri et al: *Water and Wastewater: Treatment/Volume Reduction Manual*, Page 5, Brewer Association

⁸ Spent Grain, *The Brooklyn Brewshop*, Site accessed February 2019,
<https://brooklynbrewshop.com/blogs/themash/tagged/spent-grain/>

⁹ Galitsky, Christina, et al: *Energy Efficiency Opportunities in the Brewery Industry*, Page 7, Lawrence Berkeley National Laboratory, <https://pdfs.semanticscholar.org/f3fe/87086d0f6d8127e822d8a2f22b34bb03e12b.pdf>

5. Filtration- Seems pretty straightforward right? Filter your wort for clarifying and get moving on to fermentation. Guess again! Filtering is an opportunity to actually change the chemistry of your beer. Diatomaceous Earth Filtration (DEF) is how this is done. The minerals that you use can impact beer taste, stabilization, and of course its visual appearance. Imerys Filtration's Celite Cynergy is an engineered DEF that can save time and money.¹⁰

6. Packaging- Let's be clear, your beer must taste good or no amount of innovative packaging is going to allow you to beat the competition, but if you want to stand out in the crowd, packaging can help. Crown's 360 end can that turns into a cup, or their "global vent" that allows a smooth pour from a can, are some nice innovations that your customers will remember and return to.^{11 12} *AI Suggestion: This is an area screaming for AI incorporating with the Internet of Things. Each package, can and bottle can be an "internet thing" and once connected to a network AI can manage things like Cold Chain Monitoring (did that beer stay cold from the brewery to retailer) and Inventory Management.*

Conclusion

In the end, beer production, whether you're making five gallons or 50,000 barrels, comes down to one important thing: making a great tasting beverage. To do this, you need as much concentration on the art of the brew and solid understanding of the science as you can provide to your craft. If you can use innovation, either your own or someone else's, to give you the time you need to perfect that art and science, and thus be competitive in an ever-shrinking market share, then you need to do so.

If you want to explore Artificial Intelligence, BPA and Machine Learning in Beer Brewing, ipCapital Group can assist you with any number of the steps, such as:

Figuring out your pain points or opportunities.

Getting started on the AI journey.

Creating Intellectual Property in your industry.

Examine the patentability of your own ideas and help you own the new world of AI Brewing.

About ipCapital Group, Inc.

ipCapital Group (ipCG) is an innovation and intellectual property (IP) consulting firm serving clients that range from early stage to Fortune 500 in over 1000 engagements since 1998. Drop me an email at croot@ipcg.com or call 802-859-7800 X218. Visit our website anytime at www.ipcg.com

¹⁰ Imerys Filtration, Site accessed February 2019, "Beer Filtration", <https://imerys-filtration.com/asia-pacific/applications/filtration/beer-filtration/>

¹¹ Crown Packaging, Site accessed February 2019, "Crown 360" <https://www.crowncork.com/beverage-packaging/innovations-beverage-cans/360-end>

¹² Crown Packaging, Site accessed February 2019, "Global Vent" <https://www.crowncork.com/beverage-packaging/innovations-beverage-cans/global-vent>

About the Author

Charles E Root Jr. holds a Masters Degree in Management of Information systems, and has been with ipCapital Group, Inc for 19 years as the IT Director and a Consultant. An avid homebrewer, he is also a member co-owner of the Full Barrel Cooperative Brewery in Burlington Vermont.

He also has a beer tasting review channel on YouTube concentrating (but not exclusively) on Vermont beers. <https://www.youtube.com/channel/UCY9-DrpTnW3A2GYbNfB4ufg>

