# _Measuring Software Engineering_

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# _Code_

When examining software engineering in a professional environment, there are many factors to take into account. Companies and start-ups need ways to measure the productivity of their employees, and how the current information they have about the practices of their employees' work methods can be leveraged to increase output, reduce errors, improve efficiency, and create a better working environment that will encourage better practices in the business. The types of information that is gathered around software engineering are diverse, from individual statistics about projects, either one person's program or a group project, to metadata based on a large corporations various software projects.

The most basic method of measuring a software engineers output is through the number of lines of code they have written. This is a very simple, straightforward method, but is deeply flawed. Code is not a purely linear resource, where more code equals better quality. If this were used as the defining metric for measuring performance, a very basic piece of code that is done in one line could be written out over several lines to inflate the size of their programs and thus appear to be working better. This is a minor issue at best, and potentially ruinous to software is efficiency in code is sacrificed to hit an arbitrary code quota.

Bugs per lines is another purely code-based method of measuring a software engineers' performance. This is done by counting the number of errors or bugs in a section of code and evaluating it to a metric such as bugs per 1000 lines. This method allows some level of understanding around the engineer's command of the language and also their level of comfortability with the tools at their disposal.

To measure someone's code over time can also be used to measure performance. One method is to see how much code they produce over a given time period. This could be helpful in evaluating performance, but doesn't take into account the quality of their work, or the difficultly of the project that they are undertaking. Also, the number of commits a project has, broken down by each engineer's commits and their timestamps, can also give a good indication of their work rate their habits, such as when they commit the most and the frequency of said commits. Churn rate[1] is when a developer edits their code shortly after it has been checked in. This is a normal part of the development

process, as engineers need to edit their work on a consistent basis. However, a high churn rate indicated that something is awry with their process.

While writing code, bug fixing can be an incredibly time-consuming and difficult process. Due to the need to understand the code's interaction with other software, and a fundamental understanding of what the issue is, sometimes an engineer's git pushes and coding speed can be significantly. This can give an unfairly poor impression of an engineer's work, when basing it purely on coding based metrics.

Pull requests from git are a hands-on approach to code review, allowing the team members and the team themselves to approach the various branches of the git repository. This gives people the opportunity to comment on each other's work and discuss errors or any issues within the team at large. It also gives them the chance to review the readability of the code, how well commented it is, and how closely any advice or feedback has been followed.

## _Work Environment_

An area that can greatly affect an engineer's performance is their physical work environment, i.e. their office.

The design and layout of an office area can be a strong influence on how well people are able to perform in their roles while developing software. The collaborative approach that is instrumental in organising roles,  troubleshooting, bug fixing, team meetings, and supervision of the project, are much easier to do in a well-designed and pleasant office space. While these can be done digitally using resources that will be discussed later in this paper, the ease of communication that being there physically allows can be invaluable when improving efficiency and easing through problems. This could be due to the online communication promoting passivity in engagement, a shallower conversation, and a lack of nonverbal cues (which account for 65 percent of social meaning)[2]. Digital conversations could be uses to assess the overall tone of the team however, as well as how focused on their work they are, and their treatment of each other.

As well as this, the arrangement of the office space can help workers perform their tasks quicker, more easily and efficiently, improves supervision of work, communication improves, and allows the employees to be comfortable.[3] The

temperature and lighting of these workspaces plays into this too, which in recent years has caught on with some of these ideas. Google employees report 12% of them are not stressed at work, one of the highest figures for a Fortune 500 company, due largely to their state of the art campuses and laid back work environment.[4]

These elements play into the individual need for the employees to be healthy and look after themselves both physically and mentally. Employers are more and more frequently pushing wellness programs, aimed at improving their employees' mental and physical wellbeing and improving their productivity and enjoyment levels at work. These include the chances to win holidays, work community fitness challenges, healthier canteen options, gym facilities etc.[5] This is due to the well-defined idea that physical exercise and general physical wellbeing is a key component in increased job performance and wellbeing, making companies highly incentivised to offer these things to their engineers[6].

# *Computational Methods of Measuring Software Engineering*

Due to the large demand for improved efficiency in writing code and the necessity to monitor and streamline the production and rollout of software, there is a large variety of products available to aid companies.

## Humanyze

Humanyze is a service designed, in their own words, to help companies make better, faster business decisions to improve the overall experience for all members of a company[7]. It measures productivity, engagement, and adaptability to give an overall rating of company health and point out ways an organisation can improve in these areas. The idea is that by analysing metadata from the company's networks to establish where the issues with the way the company operates and how to remove these inefficiencies.

## Velocity

Velocity is designed to analyse the pull and push requests for a company's git repositories, allowing a company to see which commits have been approved, who is committing the most, editing the most, who is pull requesting etc. This is

an automated version of the process of code reviewing that was mentioned in a previous section, but allows the process to be streamlined in a way that emphasises speed and thoroughness, according to their site[8]. They visualise this data in an attempt to show progress on a project or multiple projects over time.

## Microsoft Workplace Analytics

This is another visualisation software provided by Microsoft, designed to operate in unison with their Office 365 software. As a large portion of the world's work is done using the various platforms provided by the 365 software, this is a widely applicable tool designed, again, to visualise the way productivity, efficiency, and engagement in the workforce at your disposal can be improved and analysed to see where the time is going to[9].

## Waydev

Similar to Velocity, Waydev's service allows a company to analyse their engineer's git activity to spot inefficiencies and ways to improve your team's workflow. It monitors the repositories in real time, allowing the team leaders to spot areas for focusing more time and aid in bettering a team's time spent. By analysing pull requests, reviews of PRs, collaboration between engineers, individuals' work etc. it is thought that the output of the team will improve[10].

## Pluralsight

A company that provides a range of services in improving your skills as a programmer in some of the most widely used languages, Pluralsight's FLOW offers another alternative to the git analytics spoken about above [11]. This service allows you to not only see where the PR inefficiencies lie, but also in what languages individual engineers need to improve, as well as a way of managing the pull requests at large with a very simple visualisation.

# *Algorithmic Approaches to Measuring Software Engineering*

The use of algorithms to extrapolate information from large data sets is becoming more common in business today. The types of machine learning algorithms include supervised, unsupervised, semi-supervised, and reinforcement learning[12]. The applications of machine learning range from virtual personal assistants such as Siri or Alexa, to traffic predictions, social media recommendations, search engine autofill, and spam detection[13].

Supervised learning works by learning the mapping function between input X and output Y, i.e. f(X) = Y. The main idea behind this is providing as close an approximation as possible to predict the output (Y) when new data (X) is given. The learning is done when the mapped function is considered to have adequately approximated the given data[14].

Unsupervised learning involves the input (X) from supervised learning, with no output given. Instead, the idea for unsupervised learning is to model previously unrecognised patterns in unlabelled data. It is considered unsupervised as the outcome cannot be determined by the human user, so the outcome involves far less human interaction than supervised. They allow you to perform more complicated processes compared to supervised learning, such as neural networks and clustering[15].

Semi-supervised learning sits between the two, combining some labelled data (Y), with a large amount of input data (X). This allows you to use unsupervised techniques to make sense of the large amount, finding patterns and attributing significance to the unlabelled data that exists in the problem. This is done simultaneously using supervised techniques to construct a map for the previously unlabelled data. This data structure can then more quickly and accurately predict the output for a similarly unlabelled data set. However, this method is not as trustworthy as some supervised techniques[16].

Reinforcement learning is designed to train models to make decisions using the given data in a trial and error situation. Based on a scaled reward system, the model works on the problem with the goal of maximising the reward for the work done, which is set by the designer of the system. Through this game-like approach to machine learning, it allows the architecture to come up with numerous and increasingly improved solutions to the problems it is given[17].

## Ethical Concerns

When dealing with the computational methods of measuring performance, the ethics behind analysing people's data and holding that as a cloud based service has come into question over the last few years. Humanyze, one of the companies mentioned above, use digital badges the employees wear around their necks to track information such as who you're speaking to, the duration of these conversations, and your heart rate and voice inflection when engaged in conversation[18]. This allows the company to display the webs of social interaction that make up the day-to-day goings-on of a team work environment. While the employees would surely have to opt-in to this, and the data that is being collected by Humanyze is anonymous, there is an undeniable edge of observation and invasion of privacy that tinges this idea. In 2020 alone, Nintendo, Twitter, EasyJet, Marriott Hotels, Zoom, and many more large companies suffered data breaches[19], a lot of whom have sensitive customer data.

There are some services, such as health tracking, that cross an ethical line as far as gathering data is concerned. While there are undeniable benefits to improving your employees health, measuring their heart rates, BMI, weight over time etc. sets a dangerous precedent whereby your previously most secret information is now shared with your employer. This is becoming increasingly prevalent as a result of COVID-19's effect on working conditions and the need to be fully aware of employees' current health situation[20]. This information would need to be stored as securely as possible, which simply isn't likely considering the number of large corporations and organisations that suffer from huge data breaches[21].

The efficacy and ethics of machine learning can also be called into question. A question that has followed AI throughout its conceptual inception through to the present time when it is starting to become a mainstream and important idea, is the ethics of using an intelligence as essentially a slave to perform tasks. While this is not so much of an issue currently, as the machine learning we use is algorithmic rather than true intelligence, the ethics argument is based around the impact on humanity. How do we deal with the potential elimination of jobs, or the a potentially catastrophic mistake should machine learning and AI be allowed to control too many elements of life?[22]. While not immediately relevant, our collective response to this could be a major issue in the coming decades.

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