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Spatial Machine Learning modelling: End-to-End web App solution

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Contents

Chapter 1

Introduction

Main themes:

- (open data)
- research question
- milan market real estate
- latest improvements in the subject matter
- why both bayesian and non bayes methods
-

We are living in the big data era, so we could be brought to think that everything is a "one click" distant from us. Well, this is not totally true, moreover in some places this is truer. The main issue can be addressed to the lack of open data and the lack of relative infrastructure. This settings characterizes slow old economies and unfortunately Italy is one of them. Economies, and citizens on a later step, can largely benefit from public data and its usage. Some people in addition are in favor of the position that all data should be open. Since I am living in italy and my (Lovelace et al., 2019) goal is to an alyse market

The importance of data indeed justifies its accumulation and according to the latest reports is surpassing gold, despite these periods of uncertainty. The expression data is the new oil has never been so appropriate in these times. On the other hand is not for sure easy to assign a price amount to data due to its untangible nature. the most straightforward and liberal approach could lead us to think that the price data should be exchanged the piceThe value attributed to data is not for sure selrmarkdown::pandoc_available("1.2") f explanatory. It really depends on two major metrics: the usage that can be done through (with respect of the state of the art technology) it and the functionality with respect of other existing data. some data can be strategically important given the fact that someone already possess the complementary and can attribute some sort of competitive advantage. On the other hand as already been highlighted it really depends on the existing technology stack. Some data can be very useful but too costly either to process or to store.

$$f(k) = \binom{n}{k} p^k (1-p)^{n-k} \tag{1.1}$$

During an interesting conversation with some friends we had a discussion on how data should be treated: as a sort of currency or a sort of commodity (raw material). some people may say that the inner functioning is pretty much as a commodity. It gains value by its specialized usage and treatment. Sometimes a collection of data can represent the complementary part of a more general dataset that can not be used otherwise, in this analogy case a semi-finished product. commodities sometimes are calmed, so that their prices are fixed to a certain amount, so it is for data, the

Durante una conversazione con alcuni amici[1]

La ricerca che ho inteso fare sul mercato degli affitti a Milano mi ha aperto le porte a comprendere come poco digitalizzata e all'avanguardia sia la nostra amata penisola. L'indisposizione ai dati aperti, coperta da un sottile velo di ipocrisia chiamato privacy (ma quale?), ha reso non solo impossibile reperire

[1] footnote a caso

i dati geospaziali tramite API di alcune aree dell'italia, ma ha reso necessario che costruissi delle funzioni che li estressero, appoggiandomi a cavilli. La questione è legale e relativaemnte complessa, e di certo la tesi non si indirizza a questi problemi, ma i dati che sono stato capace di scoprire e di farlo nella assoluta legalità si appoggiano ad una mancanza di autorizzazioni al trattamento che Immobiliare.it ha nel suo sito. Un altro esempio di ritardo tecnologico riguarda l'assenza dei dati di elevazione su alcuni territori italiani. Se per esempio immobilaire, come ha fatto un altro grosso player sul mercato, avesse apposto una checkbox obbigatoria da contrassegnare con relativi termini e trattamento dei dati io non avrei potuto accedere ai dati. La situazione aldifuori dell'italia è abbastanza uniforme, eccetto qualche paese noto come Germania e Francia, e meno noto come la Polonia, con tutte altre piattaforme e regole di trattamento dati. La domanda quindi sorge spontanea, perchè i dati degli italiani e degli europei sono meno accessibili dei dati degli americani? Mentre in America è sufficiente richiamare un API con latitudine e longitudine della quadrettatura di terra necessaria per ottenere i dati[2] di elevazione (.tif), in Italia l'unica soluzione è pagare google che tramite le sue private API è in grado di venderceli dietro autenticazione. La risposta aldilà dei confini della legge presumibilmente risiede in un congiunturale ritardo di infrastrutture tecnologiche condivise e di indirizzo comune europeo sulla questione. L'esigenza di dati aperti nasce per la risoluzione di problemi comuni a tutti, i dati sanitari hanno la missione di tentare risolvere problemi di natura sanitaria, i dati economici auspicabilmente curano probelmi o asimmentrie di un mercato. Il mercato degli affitti a Milano gode di sempiteerna gloria e ha visto la crescita degli affitti e dei prezzi degli immobili di paripasso al punto che una bolla è stata presunta. Diversi fattori hanno reso tale il fenomeno e diverse opinioni si sono spese sul tema. Alcuni pensano che dopo Expo la città abbia goduto di una spinta economia e innovativa che l'ha resa un'isola felice in mezzo ad un'italia che affanna. Altri ritengono che Milano goda di ottime infrastrutture, ma che la sua notorietà ed il suo appeal si sia sostituito a tutto

[2]https://it.wikipedia.org/wiki/Dato

quello che manca nelle altre città, ma che in Milano appare. La mia opinione è che sia una media di questi due pareri. Un altro fattore è imporatante nella descrizione del fenomeno: l'asimmetria di infromazione tra chi cerca casa a Milano venendo da fuori e colui che affitta. Tale asimmetria viene ancora più esasperata al crescere della fretta che l'entrante ha nel trovare la locazione opportuna. La scelta diventa in molti casi antieconomica, nello specifico la domanda si genuflette all'offerta e accetta le svattaggiose condizioni proposte. Infatti quello che appare certo è che i prezzi degli affitti se comparati ai salari per posizioni junior e di stage è falsato. Proprio qui nasce l'esigenza di approfondirne il perchè e fornire all'utente finale (un potenziale studente, un futuro lavoratore etc.) uno strumento che gli permetta di capire il prezzo stimato tramite predizione spaziale date le coordinate geografiche e gli attributi dell'appartamento e contestualmente fornire un mezzo di comparazione per altri immobili nelle vicinanze. Dall'altro lato dia un'idea chiara a chi vuole dare in affitto l'immobile, un prezzo rappresentativo, che ha fondamento nel modello utilizzato e nelle assunzioni che lo stesso modello impone alla realtà. Questo fa sì che da entrambi i lati ci sia trasparenza e che eventuali maggiorazioni di prezzo richiesto rispetto al sopradetto modello vengano penalizzate in favore di sconti applicati su altri immobili. Auspicabilmente i prezzi già gonfi si smusseranno in tutta la regione spaziale considerata, adattandosi alla domanda piuttosto che al capriccio dell'offerta.

Chapter 2

Scraping

(Lovelace et al., 2019)

Lo web scraping è una tecnica di estrazione dei dati da pagine internet statiche o dinamiche in maniera automatica e simulatanea (Wikipedia, 2020). L'impossibilità di reperire dati aperti aggiornati riguardo l'affitto sul mercato italiano mi ha spinto a sviluppare sofisticate tecniche di estrazione di dati orientate ad alleggerire lo sforzo e aumentare la velocità di reperimento: da una parte nel preprocessing del dataset, nella successiva del fragente del modelling, per finire con la reattività di risposta dell'applicazione. Le informazioni sui siti appaiono spesso ordinate e semplici, tuttavia ogni sito web ha una propria architettura e un proprio linguaggio. Per architettura intendo struttura gerarchica secondo cui è organizzatto un sito internet: una semplificazione della struttura di un sito web può essere un insieme di cartelle innestate una dentro l'altra collegate tra loro da riferimenti tramite l'url. la natura gerarchica della struttura prevede che si usi un linguaggio che fa propria questa caratteristica, HTML è il preferito. L'html si organizza in nodi ed angoli, esattamente come un grafo; che aggiunta la componente gerarchica fa sì che questo sia un albero. Difatti spesso ci si riferisce alla struttura delle pagine web come html tree. Ogni elemento nella pagina ha un suo preciso posto nel codice sorgente della stessa e ha un preciso valore o più valori. Possiamo immaginare ogni nodo della pagina come una lista di valori che

è collegata ad un nodo precedente detto padre da una struttura gerarchica superiore, ed eventiualmente ad un nodo successivo detto figlio. Pertanto tutte le informazioni che giacciono sotto al nodo padre sono parenti del nodo padre e sono direttamente collegate (directed nel senso dell'interpretazione), parallelamente ci saranno altri nodi padre che saranno adiacenti al nodo padre, i quali avranno nodi figli e così via. La complessità della pagina e del codice è tanto maggiore quanto il livello dell'albero aumenta, tanto più l'albero è folto tanto più sarà difficile individurare il ramo o la foglia che ci interessa. Ragionevolemnte accade lo stesso per la funzione di scraping e il tempo di scraping. Html organizza i contenuti e le relazioni tra loro, il css (Cascading Style Sheets) invece si occupa dello stile e della formattazione degli stessi. il css è uno strumento molto potente in mano ad uno scraper perchè permette di recuperare informazioni simili tra loro ma che occupano nodi con posizione gerarchica diversa all'interno della pagina. Pertanto una volta letto l'html della pagina sarà necessario recuperare la query css per raccogliere tutti gli elementi di interesse tramite la funzione di scraping. Successivamente occorre notare che l'encoding da html a stringa di testo non è quasi mai lineare, spesso occorre riformattare, cancellare spazi, convertire la natura dell'oggetto estratto etc. Il successivo elemento di complessità incontrato durante questa prima fase è stato interfacciarsi con un server attento alle richieste GET degli utenti. I dati viaggiano in pacchetti da un server che ospita un sito internet al nostro laptop. tutte le volte che cerchiamo di accedere ad un sito stiamo mandando una richiesta di ricezione di pacchetti dati ad un server in qualche luogo remoto del mondo. Quandi bussiamo alla porta del server se non siamo sospetti e superiamo i criteri autostabiliti dal server questo risponde, e lo fa con un numero che spazia da 200 a 500, due esempi: 200 se la risposta è positiva, 404 se la risposta è negativa. I criteri secondo cui gli utenti sono calssificati secondo utente normale o utente sospetto (aka bot) sono sintetizzati in un documento di testo chiamato robot.txt. Questo file di testo raccoglie tra le altre due infromazioni principali il delay time, cioè il tempo preferito dal server che deve intercorrere tra una richiesta dati e la successiva

e quale utente è autorizzato ad accedere. Ogni utente posside un indirizzo IP che nelle richieste a server si codifica in user agent, cioè una stringa di testo dove vengono raccolte le infromzioni significative circa il dispositivo da cui provengono le richieste, un esempio:

'Mozilla/5.0 (Windows NT 10.0; WOW64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/54.0.2840.71 Safari/537.36',

dove ogni segmento della stringa rispecchia una caratteristica del laptop del richiedente, Chrome/54.0.2840.71 è la versione del browser chrome da cui proviene la richiesta Safari/537.36', è il motore di ricerca etc.

- Copia e incolla manuale
- Web scraper
- HTML parsing
- Analisi con Visione computerizzata
- DOM parsing
- Riconoscimento dell'annotazione semantica
- Aggregazione verticale
- Text pattern matching

funzioni di scraping.

Chapter 3

Infrastructure

In order to provide a fast, portable and integrated product to the end user It has been designed a quite straightforward software architecture. We have already seen the scraping functions and how they are built around the concept of easy flexibility and debugging. This is due to the fact that they should extract something that is dynamic, it is not sure that it will be as the day before. The data we are trying to grab might have been moved somewhere else throughout the website. Or it might have placed extra expression inside the node we are inspecting ("$" sign following the monthly rental price) . A very often occurring example regards the way information concerning the house are represented in the website. Considering the september 2018 january 2020 time span the design of the website has changed a vast number of times. Since both the design and the scrapping functions relies on the HTML skelethon and CSS queries. As soon as something changes in the website the other files needs to be readjusted to be consistent with the content and so back and forth. The debugging handlers nested in the functions helps the maintainer to grasp what it is not working properly where the error occur. The same inner philosophy has been applied to the software architecture chosen for this project. First of all the wide range of open source solutions (back-end and front-end) and documentation on this has made many analyst and data scientist almost full stack developer. This was also due to the fact that RStudio has set very well

oriented guidelines spending a lot of effort giving its users an easy, integrated and interconnected environment. By that it is meant that recently the RStudio community has developed, on top of many different others, an entire package dedicated to REST APIs (Plumber (Trestle Technology, LLC, 2018)). MOreover developers in RStudio and its contributors have created an entire new paradigm called Shiny (Chang et al., 2020), a popular web app development package, that forces the user to have front-end and back-end technologies tied up in the same IDE (RStudio) and with a unique language to deal with. The front end file (for simplicity named UI.R) contains the UI's layout and the style and also other javascripts components. On the other hand the server file (named after server.R) absorbs the back-end, under the hood, code and makes the UI intercact and respond to the user. This comes at a cost of flexibility and customization since Shiny could not easily handle too many embellishments (even though potentially can). Nevertheless a unique environment makes integration with other technologies easier and most of all introduces the analyst to a full stack approach. Many open source projects are gravitating around the Shiny framework with the aim to extend its capabilities. One example is a newly created package called reactR (Inc et al., 2020) that allows user to implement the power of React.js into the shiny UI front end. All of this is possible, once again, by the R community but a greater contribution come from digging up the right path along which everything by open source comes natural. (parallelo con la vigna e l'albero che la sostiene e indirizza) The carrier idea for this project is to have parallelized scraping functions called daily by a scheduler producing and subsequently storing a .csv file in a MySQL /cartoDB database. They are all tought to be containerized in a Linux (Ubuntu distr) docker container hosted in a AWS EC2 server. Then in a second container a Shiny app is placed, this one pipes in data from the former infrastructure and apply the statistical model stored (by an API call) in its server.R part.

The main technologies implied are:

- Scheduler cron job

- Docker containers
- Shiny
- Plumber REST API
- AWS (Amazon Web Services) EC2
- CartoDB

On top of that even each single part of this thesis has been made stand alone and can be easily accessed and modified through this link[1]. The pdf (theis) version of the gitbook can be obtained by clicking the download button that can be seen in figure below. A Latex engine (Xelatex) wrapped into the website compiles a sequence of Markdown documents converting them into .html (the book's chapters) which are formatted by rules grouped in a .yml file. All the documents are pushed to a Github repository with git. By a simple trick, since all the files are static html, they can be displayed through GH pages as it is a website. All of this has been possible thanks to Bookdown (Xie, 2020) once again a R well documented package (Xie, 2016) to build interactive books along with RMarkdown (Allaire et al., 2020).

An empirical observation of immobiliare.it has suggested that houses rents advertisement are continuously added and then removed during the day. Fresh data is needed to have updated analysis since the scope in here is to offer realtime considerations. Something should be automated periodically in order to address the issue. Moreover, as rule of thumb, a daily data extraction might be a good option for some reasons. It can intercept price variations with a relatively small time lag, It can also display some sort of pattern in time that would help the reader/user to select the perfect choice. As a consequence a daily .csv file is generated and directly collected into a Db folder arranged by time The solutiond proposed takes care of the issue by making the scraping script generating the .csv be executed by a scheduler.

[1] https://niccolosalvini.github.io/Thesis/

3.1 Scheduler

A Scheduler in a process is a component on a OS that allows the computer to decide which activity is going to be executed. In the context of multi-programming it is thought as a tool to keep CPU occupied as much as possible. As an example it can trigger a process while some other is still waiting to finish. There are many type of scheduler and they are based on the frequency of times they are executed considering a certain closed time neighbor.

- Short term scheduler: it can trigger and queue the "ready to go" tasks
  - with pre-emption
  - without pre-emption

The ST scheduler selects the process and It gains control of the CPU by the dispatcher. OIn this context we can define latency as the time needed to stop a process and to start a new one.

- Medium term scheduler
- Long term scheduler

for some other useful but beyond the scope information, such as the scheduling algorithm the reader can refer to (Wikiversità, 2020).

The scheduler in this context cosists in a .sh (shell file, sort of text file) composed by a set of instructions that are being executed by the computer on daily basis. This file has to be in the same WD (working directory) of the project in order to make it working. Some common issues can occur when new files coming after the execution of the scheduled main script are generated, but the path isnt explicitly specified. This can lead to the partial or incomplete generation of the file since the shell file is executed within the folder but is triggered by some other location on the computer. Each OS has its own scheduler and syntax to call it. Since we are interested in Ubuntu machines the scheduler

is said to be a cron job. Later it will be clear why Ubuntu is the option to pursue.

va parafrasato

3.1.1 Cron Jobs

The software utility cron also known as cron job is a time-based job scheduler in Unix-like computer operating systems. Users that set up and maintain software environments use cron to schedule jobs (commands or shell scripts) to run periodically at fixed times, dates, or intervals. It typically automates system maintenance or administration—though its general-purpose nature makes it useful for things like downloading files from the Internet and downloading email at regular intervals.

The actions of cron are driven by a crontab (cron table) file, a configuration file that specifies shell commands to run periodically on a given schedule. The crontab files are stored where the lists of jobs and other instructions to the cron daemon are kept. Users can have their own individual crontab files and often there is a system-wide crontab file (usually in /etc or a subdirectory of /etc) that only system administrators can edit.

Each line of a crontab file represents a job, and looks like this:

```
# ┌──────────── minute (0 - 59)
# │ ┌────────── hour (0 - 23)
# │ │ ┌──────── day of the month (1 - 31)
# │ │ │ ┌────── month (1 - 12)
# │ │ │ │ ┌──── day of the week (0 - 6) (Sunday to Saturday;
# │ │ │ │ │                                7 is also Sunday on some systems)
# │ │ │ │ │
# │ │ │ │ │
# * * * * * <command to execute>
```

Figure 3.1: crontab

Each line of a crontab file represents a job. This example runs a shell program called scheduler.sh at 23:45 (11:45 PM) every Saturday.

45 23 * * 6 /home/oracle/scripts/scheduler.sh

Some rather unusual scheduling definitions and syntax for cronjobs can be found in this reference (Wikipedia contributors, 2020)

The cron job applied to the script needs to be ran at 11:30 PM everyday. It has that forms: —> qui immagine

va parafrasato

For now the computational power comes from the machine on which the system is installed. A smarter solution takes into consideration that the former infrastructure has its own limits. Major limits comprehend run time since at the same moment the machine runs locally both the scraping functions and the app computations. This to a certain extent might fit for personal use but as data increases all the system risks to fail. It is also totally local so the analysis can not be shared with anyone. This problem can be addressed with a technology that has seen a huge growth in its usage in the last few years: Docker containers.

3.2 Docker Container

from docker In 2013, Docker introduced what would become the industry standard for containers. A container is a standard unit of software that packages up code and all its dependencies so the application runs quickly and reliably from one computing environment to another. A Docker container image is a lightweight, standalone, executable package of software that includes everything needed to run an application: code, runtime, system tools, system libraries and settings.

3.2.1 What is Docker

Container images become containers at runtime and in the case of Docker containers - images become containers when they run on Docker Engine. Available for both Linux and Windows-based applications, containerized software will al-

ways run the same, regardless of the infrastructure. Containers isolate software from its environment and ensure that it works uniformly despite differences for instance between development and staging.

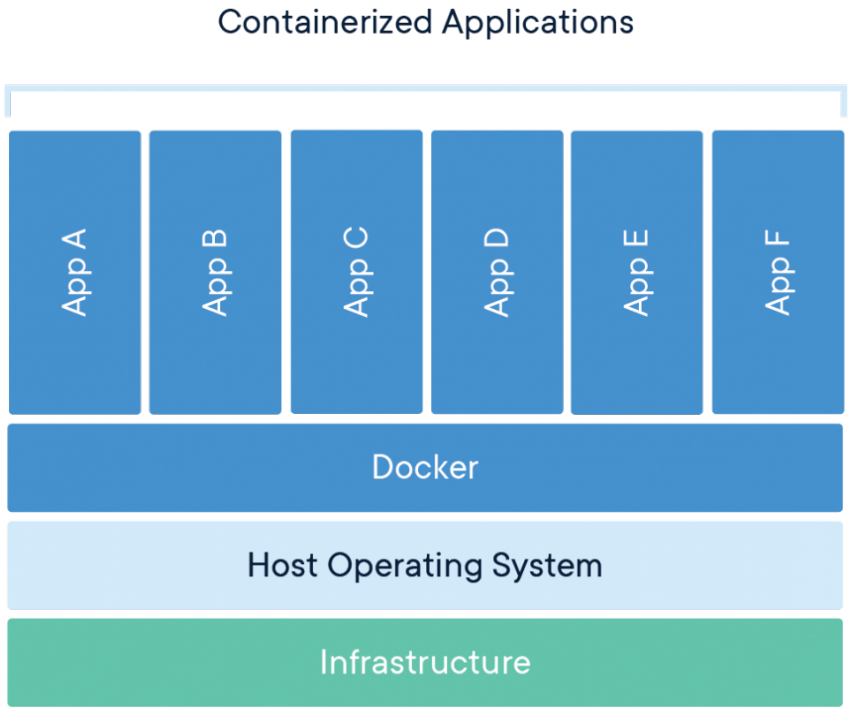
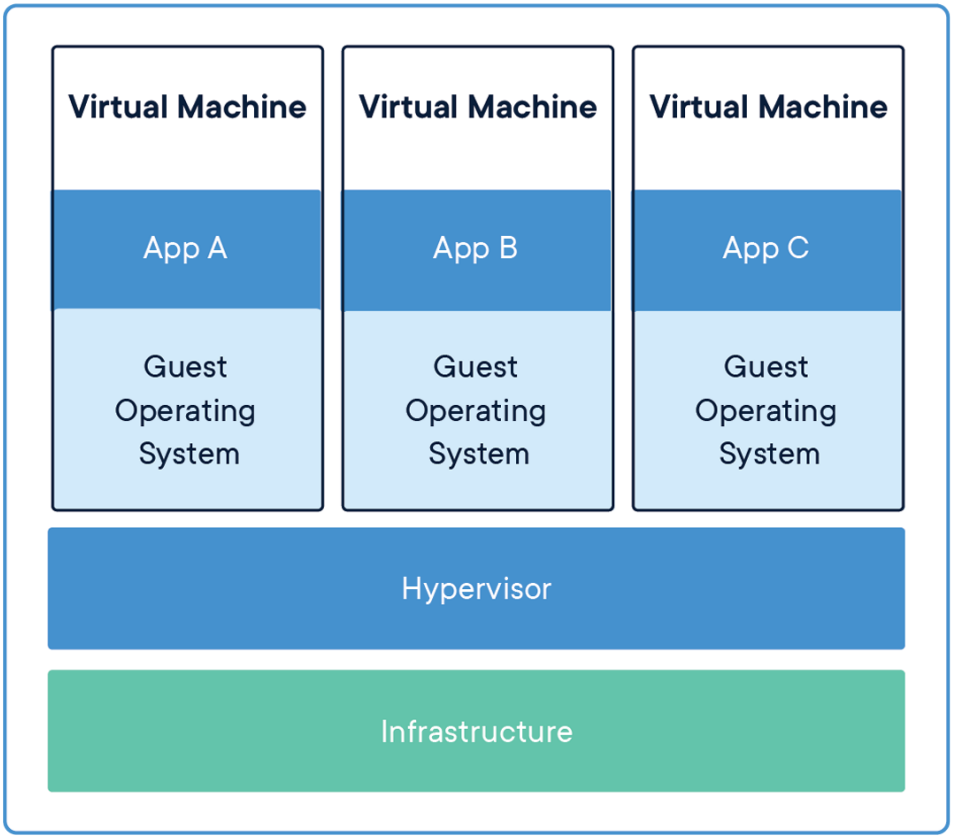


Figure 3.2: docker example

Docker leveraged existing computing concepts around containers and specifically in the Linux world. Docker's technology is unique because it focuses on the requirements of developers and systems operators to separate application dependencies from infrastructure.

A question might come up about why a Virtual Machine could not be a preferable container for our specified task. Well, Containers and virtual machines have similar resource isolation and allocation benefits, but function differently because containers virtualize the operating system instead of hardware. Containers are more portable and efficient.



from docker

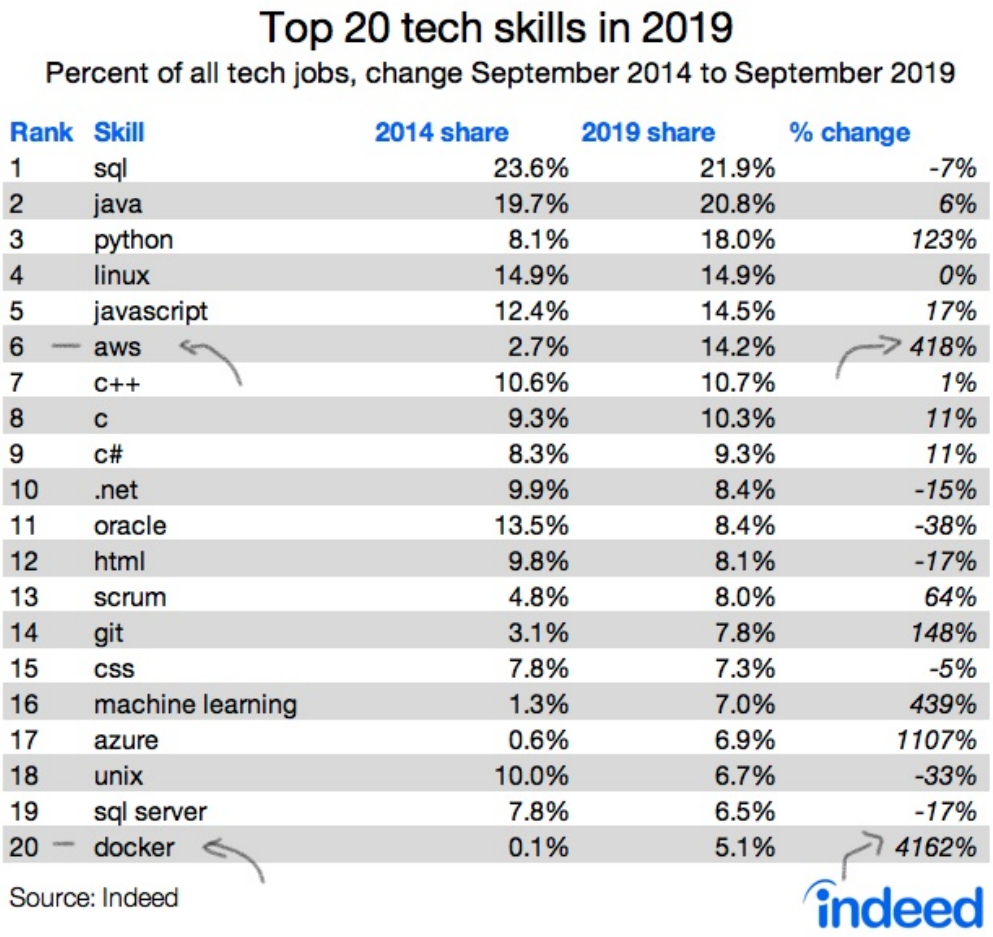
3.2.2 Why Docker is a top skill

va parafrasato from Matt Dancho

Indeed, the popular employment-related search engine, released an article this past Tuesday showing changing trends from 2015 to 2019 in "Technology-Related Job Postings". We can see a number of changes in key technologies - One that we are particularly interested in is the 4000% increase in Docker.

The landscape of Data Science is changing (was previously an Economist at the Indeed Hiring Lab, 2020) from reporting to application building:

In 2015 - Businesses need reports to make better decisions In 2020 - Businesses need apps to empower better decision making at all levels of the organization This transition is challenging the Data Scientist to learn new technologies to stay relevant...



Top 20 tech skills in 2019

Percent of all tech jobs, change September 2014 to September 2019

Rank	Skill	2014 share	2019 share	% change
1	sql	23.6%	21.9%	-7%
2	java	19.7%	20.8%	6%
3	python	8.1%	18.0%	123%
4	linux	14.9%	14.9%	0%
5	javascript	12.4%	14.5%	17%
6	aws	2.7%	14.2%	418%
7	c++	10.6%	10.7%	1%
8	c	9.3%	10.3%	11%
9	c#	8.3%	9.3%	11%
10	.net	9.9%	8.4%	-15%
11	oracle	13.5%	8.4%	-38%
12	html	9.8%	8.1%	-17%
13	scrum	4.8%	8.0%	64%
14	git	3.1%	7.8%	148%
15	css	7.8%	7.3%	-5%
16	machine learning	1.3%	7.0%	439%
17	azure	0.6%	6.9%	1107%
18	unix	10.0%	6.7%	-33%
19	sql server	7.8%	6.5%	-17%
20	docker	0.1%	5.1%	4162%

Source: Indeed

indeed

Figure 3.3: docker-stats

As a matter of fact, it is no longer sufficient to just know machine learning algorithms. Future data workers need to know how to put machine learning into production as quickly as possible to meet the business needs. This can be done either integrating existing technologies, or build a solid, portable and scalable infrastructure. To do so, we need to learn from the Programmers the basics of Software Engineering that can help in our quest to unleash data science at scale and unlock business value.

3.2.3 Dockerfile

Docker can build images automatically by sort of interpreting the instructions from a Dockerfile. A Dockerfile is a text format document that contains all the commands/rules a generic user could call on the CLI command line to assemble an image. Executing the command from shell in docker build users can trigger the building that executes several command-line instructions in chronological succession of steps. The Dockerfile used to trigger the build of the docker image has this following set of instructions:

Figure 3.4: dockerfile

- `FROM rocker/r-ver:4.0.0` : the command imports an image already written by the rocker team (authored contributors for the R docker project) that contains the base-R version 4.0.0. Since recently with the 4.0 version the RStudio team has created a repository management server for its packages to organize and centralize R packages (offline access and checkpoints). This will shorten the installation time and secure packages since they all can be freezed into a version that make the whole system works.

- `RUN R -e "install.packages(c('plumber','tibble','magrittr','rvest','tidyr` : the command install all the packages required to execute the files (R files) containerized for the scraping. Since all the packages have their represctive and shared dependencies the option `dependencies=TRUE` must be set boolean TRUE.

- `EXPOSE 8000` : the commands instructs Docker that the container listens on the specified network ports at runtime. It is possible to specify whether the port exposed listens on UDP or TCP, the default is TCP.

- `ENTRYPOINT ["Rscript", "main.R"]` : the command tells docker to execute the Rscript extension file main.R that triggers the API building.

va parafrasato from Matt Dancho

3.2.4 What are the main Advantages for Docker

from RedHat

Docker brings in an API for container management (red, 2020), an image format and a possibility to use a remote registry for sharing containers. This scheme benefits both developers and system administrators with advantages such as:

- *Rapid application deployment* : containers include the minimal run time requirements of the application, reducing their size and allowing them to be deployed quickly.
- *Portability across machines* :an application and all its dependencies can be bundled into a single container that is independent from the host version of Linux kernel, platform distribution, or deployment model. This container can be transfered to another machine that runs Docker, and executed there without compatibility issues.
- *Version control and component reuse* : you can track successive versions of a container, inspect differences, or roll-back to previous versions. Containers reuse components from the preceding layers, which makes them noticeably lightweight.
- *Sharing* : you can use a remote repository to share your container with others. It is also possible to configure a private repository hosted on Docker Hub.
- *Lightweight footprint and minimal overhead* : Docker images are typically very small, which facilitates rapid delivery and reduces the time to deploy new application containers.
- *Simplified maintenance* :Docker reduces effort and risk of problems with application dependencies.

So, Docker technology is a more granular, controllable, microservices-based approach that places greater value on efficiency.

from RedHat

3.3 API

va parafrasato

The scraping functions, in the way they are designed, can produce two .csv extension (if the boolean `write = TRUE`) files that at some point should be

joined by a primary key. But for the sake of In order to give the possibility to have a daily updated saptial analysis on data we need to continously have fresh data. In the website data come and go, as products in a marketplace, so the main idea is to have something that catches the new added and deletes what it is already taken. Nowadays we have many open source, nearly cost free, techonlogies that allow us to have corporate grade applications that can be orizontally scaled at need. Most of them come with great docuemntation and ready to use examples that flatten the learning curve. The first choice that has to be made is: either to provide a .csv file day by day with all the data to feed the application, or we exploit some portable and fast solutions as API.

va parafrasato

3.4 What an API is

API is a set of definitions and protocols for building and integrating application software. API stands for application programming interface.

APIs let your product or service communicate with other products and services without having to know how they're implemented. This can simplify app development, saving time and money. When you're designing new tools and products—or managing existing ones—APIs give flexibility; simplify design, administration, and use; and provide opportunities for innovation.

APIs are sometimes thought of as contracts, with documentation that represents an agreement between parties: If party 1 sends a remote request structured a particular way, this is how party 2's software will respond.

Because APIs simplify how developers integrate new application components into an existing architecture, they help business and IT teams collaborate. Business needs often change quickly in response to ever shifting digital markets, where new competitors can change a whole industry with a new app. In order to stay competitive, it's important to support the rapid development

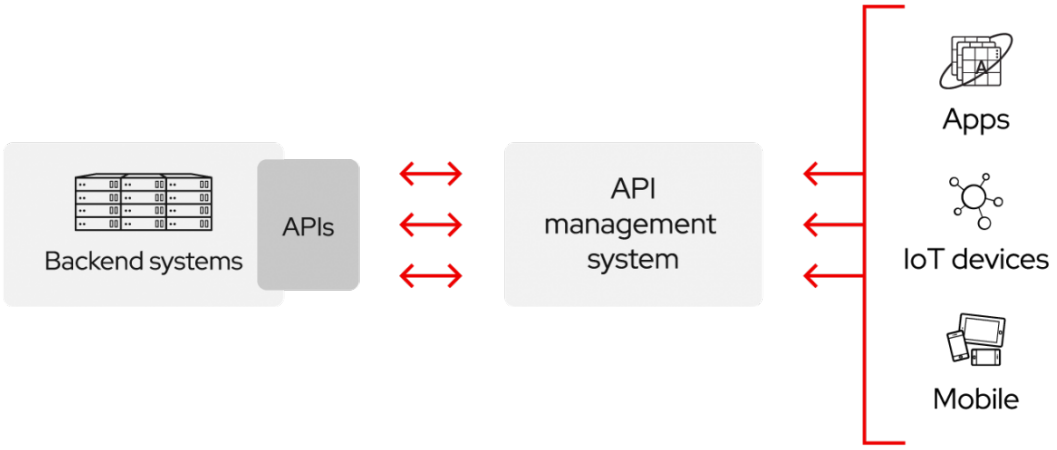


Figure 3.5: API functioning

and deployment of innovative services. Cloud-native application development is an identifiable way to increase development speed, and it relies on connecting a microservices application architecture through APIs.

(va prafrasato)

Since website are continuously changed for many reasons API philosophy results in the smartest choice since it makes easy to access data and flex API endpoints to the needle.

Chapter 4

Methodologies

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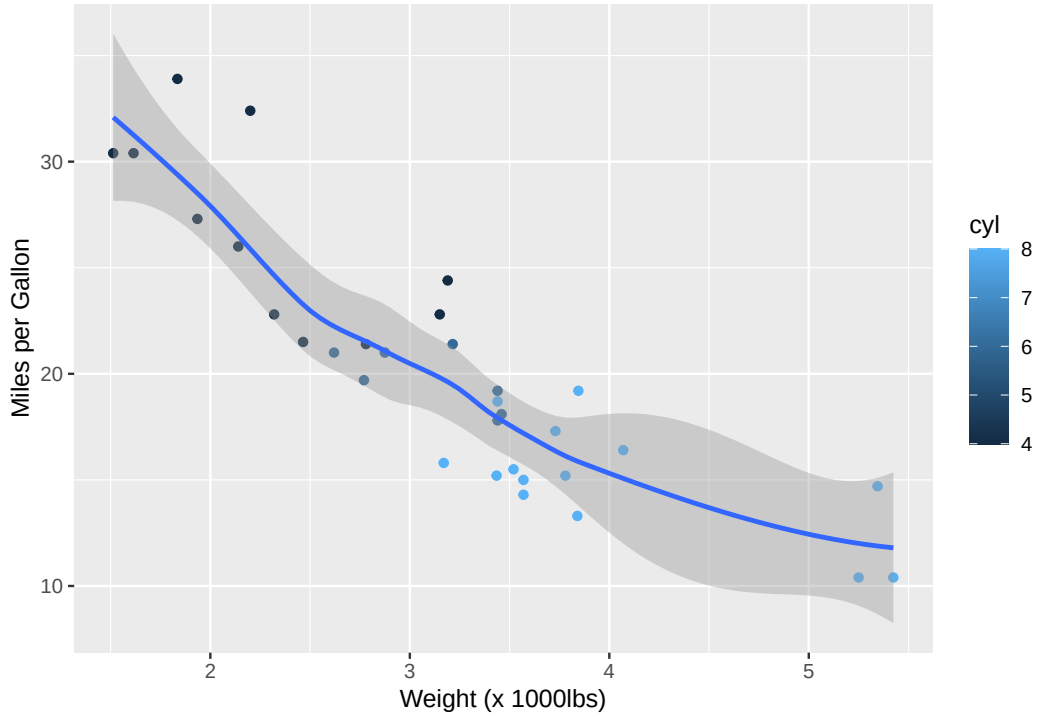
library(tidyverse)
my_scatplot <- ggplot(mtcars,aes(x=wt,y=mpg, col=cyl))+
  geom_point() +
  xlab('Weight (x 1000lbs)') +
  ylab('Miles per Gallon') +
  geom_smooth()
my_scatplot
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```



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Chapter 5

Applications

Some *significant* applications are demonstrated in this chapter.

5.1 Example one

5.2 Example two

Chapter 6

Final Words

We have finished a nice book.

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