DATA SCIENCE IN MANUFACTURING

WEEK 1

ANDREW SHERLOCK, JONATHAN CORNEY, DANAI KORRE

LECTURE: WEEK 1

Introduction to the course and the manufacturing context

BY THE END OF THIS LECTURE YOU SHOULD:

Understand how the course will work

Know what learning resources are available

Understand what you need to do and how you will be assessed

Develop an understanding on how data science can be applied to manufacturing

INTRODUCTION

- About this course
- General Information
- Learning Objectives
- Syllabus

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In this course you will be supported in developing a computational mindset, learning the tools of software carpentry, and developing a competence in writing and managing software in a manufacturing context. Building on this, you will be introduced to the importance of data in contemporary manufacturing throughout the product lifecycle and current paradigms of data management. Alongside this, you will develop an understanding of data, from microformats to large datasets. This includes: simple descriptive statistics; exploratory visual analysis; finding, combining and relating datasets (data wrangling); and how to draw inferences from data.

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The course is developed to facilitate hybrid teaching and is compromised of a series of lectures, tutorials and workshop sessions that will encourage student-centred learning. A combination of technical lectures, guest speakers from industry and practical manufacturing experience will be employed to allow students to make informed decisions regarding the selection and effective implementation of such manufacturing approaches.

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Upon successful completion of this course, you should be able to:

1. Give a grounding in programming with Python, version control with Git and Github and other key software practices.
2. Develop an understanding of data formats, their wrangling and management, including CSV and relational databases (SQL), CAD formats and materials.
3. Develop skills in the analysis and visualisation of a range of data using descriptive statistics and exploratory data analysis.
4. Introduce you to the ramifications of data collection and use in a manufacturing setting.
5. Criticise data use and practises

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6. Introduce collaborative practices around data collection, analysis and presentation.
7. **Set some context**
    a. What types of data can be found in manufacturing
    b. How that data can be used on a big level
    c. Tactically how the data can be used to optimize processes
8. **Particular topics**
    a. Data Carpentry
    b. Data visualization
    c. Machine Learning/Data Analysis/Data Carpentry

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LO1 - Program : Identify and deploy strategies for writing, understanding and managing computer programs using Python and version control.

LO2 - Data : The ability to handle, analyse, learn from and visualise a range of data, in a way that demonstrates its relevance to digital manufacturing and create data-driven solutions for various business use-cases.

LO3 - Communicate : Communicate around manufacture relevant issues, supported by the use of multiple data sources and appropriate analysis.

LO4 - Professionalism : Working in collaborative, interdisciplinary teams to a high professional standard.

LO5 - Understanding the data ecosystem of manufacturing companies

- About this course
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- **Syllabus**

Week	Lecture	Workshop/ Tutorial
1	Introduction and Foundations	Intro to Python programming and Jupyter Notebooks
2	Data Carpentry	Git and data carpentry introduction
3	Product Lifecycle / Material Flow	Data cleaning and data carpentry
4	Data visualization and Exploratory Data Analysis	Data visualisation Exploratory Data Analysis
5	Current Manufacturing Software / PLM / ERP /MES	Data Representation / Relational databases
6	ML/AI	Jupyter Notebooks and Machine Learning (ML)
7	Asset Management / IoT	ML and visual Exercise (Time series)
8	EBoM / MBoM / Geometry / Time Series	ML and vis Exercise
9	Data for Industry 4 / New Business Models/Digital Twin / Thread	Presenting Information
10		Assessment

ABOUT ME

1995-1998. **PhD in 3D shape optimisation**, University of Edinburgh

1998-2000. **Research Engineer**, Mathématiques Appliquées S.A.

2000-2005. **Lecturer at University of Edinburgh**: *Search algorithms in 3D CAD, numerical simulation of electrochemical machining of titanium aluminide*

2006-present. **CEO ShapeSpace**: *Spin-out for 3D shape search technology and engineering analytics projects*

2012-2015. **VP Engineering Actify Inc**: *CAD software development. Ran development teams in San Francisco, CA, Edinburgh, UK and Minsk, Belarus.*

ABOUT ME

2016-2019. **Royal Academy of Engineering Visiting Professor at Uni of Edinburgh**

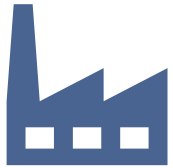
2019-2020. **Secondment at Babcock Rosyth.**

2019-2020. **Senior Lecturer (part-time) at Uni of Edinburgh.**

2020-2021. **Industrial Chair of Data-driven Manufacturing (part-time) at Uni of Edinburgh.**

Aug 2021 - Present. **Director of Data-driven Manufacturing (part-time) at NMIS.**

LECTURES



Week 1

Introduction and Foundations

Week 2

Data Carpentry

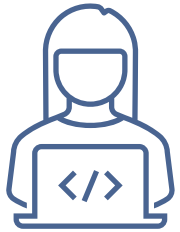
Week 3

Product Lifecycle/ Material Flow

LECTURES

Week 4

Data Visualisation and EDA



Week 5

Current Manufacturing Software / PLM / ERP /MES

Week 6

Machine Learning and Artificial Intelligence (ML/AI)

LECTURES

Week 7

Asset Management / IoT

Week 8

EBoM / MBoM / Geometry / Time Series

Week 9

Data for Industry 4 / New Business Models/Digital Twin / Thread

WORKSHOPS

Intro to Python programming and Notebooks	Git and data carpentry introduction	Data carpentry and data cleaning	Data visualisation and Exploratory Data Analysis (EDA)
Data Representation / Relational databases	Notebooks and ML	ML and visual based exercise (Time series)	ML and visualisation exercise (Data mining factory data)
	Presenting Information	Assessment (support)	

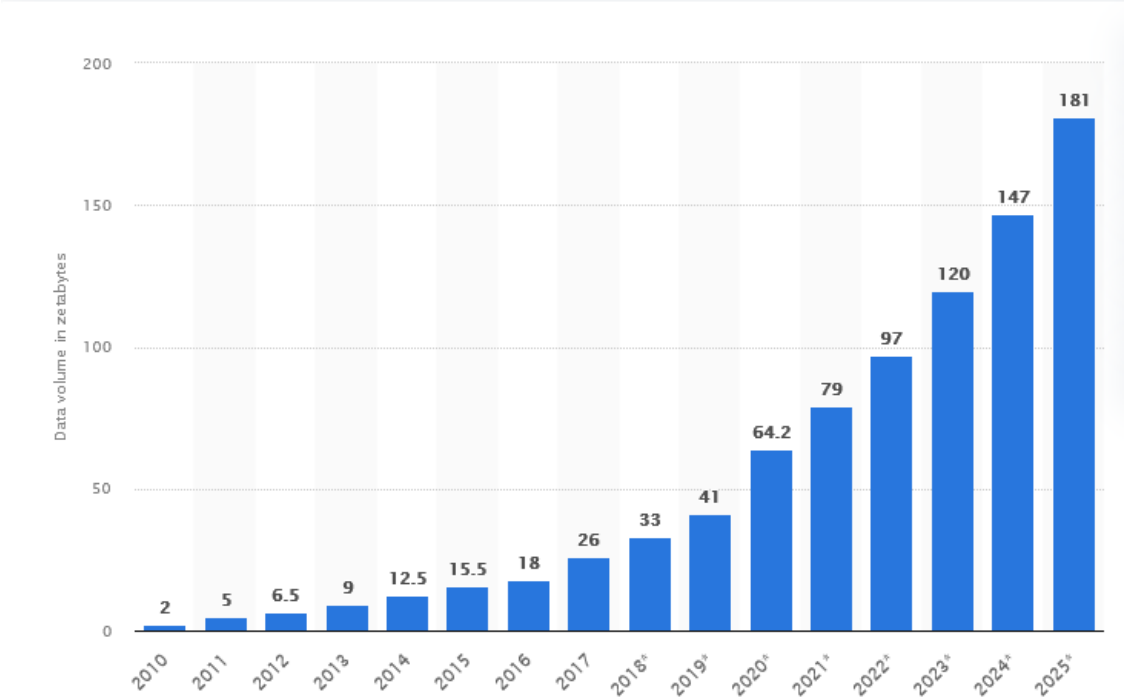
WHAT IS DATA SCIENCE?

Data science implies a focus involving data and, by extension, statistics, or the systematic study of the organization, properties, and analysis of data and its role in inference, including our confidence in the inference [1].

WHAT IS DATA SCIENCE?

Data science is different from statistics and other existing disciplines in several important ways:

- the "data" part of data science, is increasingly heterogeneous and unstructured text, images, video often emanating from networks with complex relationships between their entities [1].



Volume of data/information created, captured, copied, and consumed worldwide from 2010 to 2025 (in zettabytes). Source: Statista

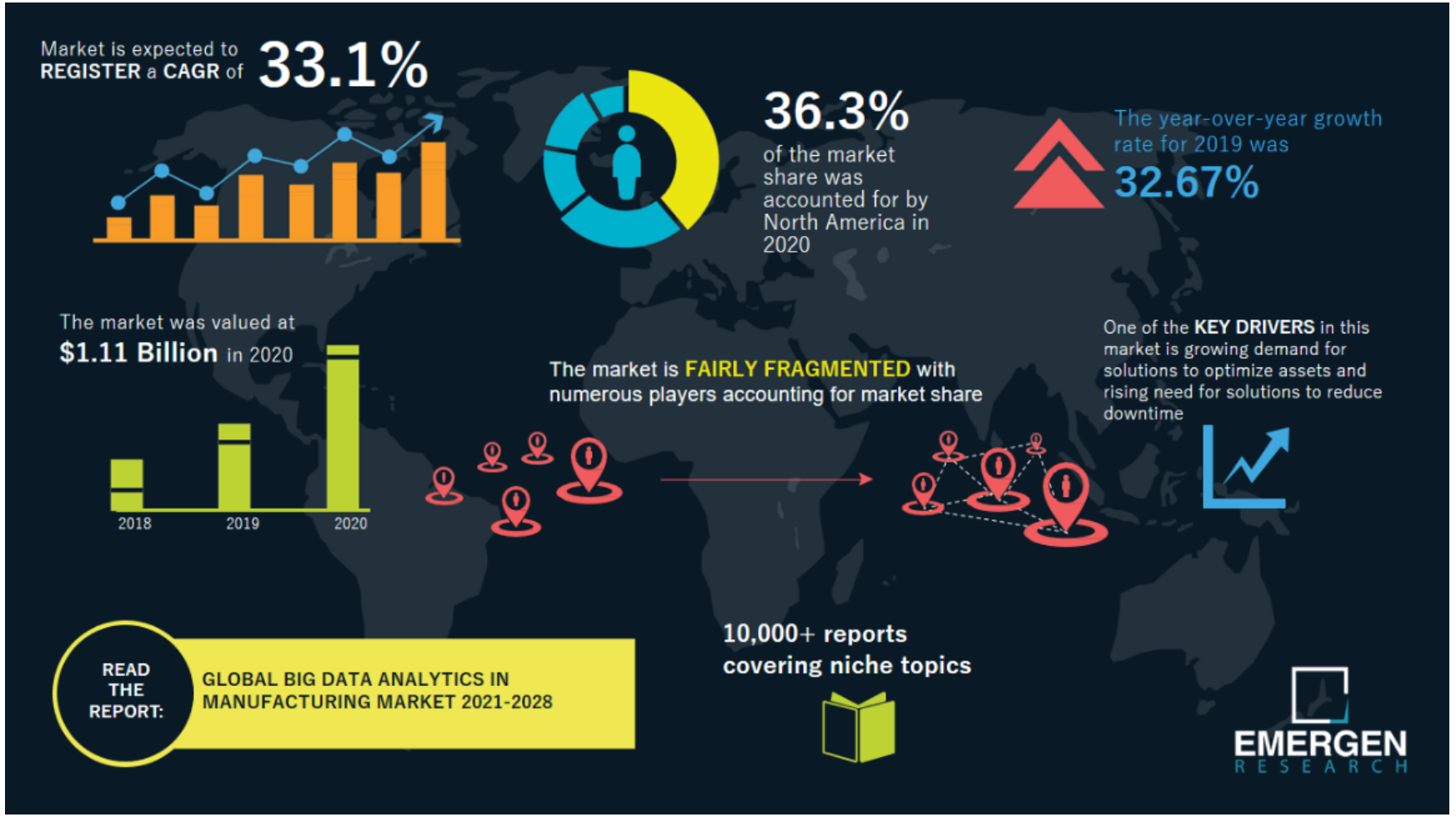
WHAT IS DATA SCIENCE?

- Analysis, including the combination of the two types of data, requires integration, interpretation, and sense making that is increasingly derived through tools from multiple fields. Most data generated by humans and computers today is for consumption by computers [1].

WHAT IS DATA SCIENCE?

Scalability in decision making has become possible because of big data that serves as the raw material for the creation of new knowledge . From an engineering perspective, scale matters in that it renders the traditional database models somewhat inadequate for knowledge discovery. Traditional database methods are not suited for knowledge discovery because they are optimized for fast access and summarization of data, given what the user wants to ask, or a query, not discovery of patterns in massive swaths of data when users lack a well-formulated query [1].

HOW BIG IS DATA SCIENCE IN MANUFACTURING?



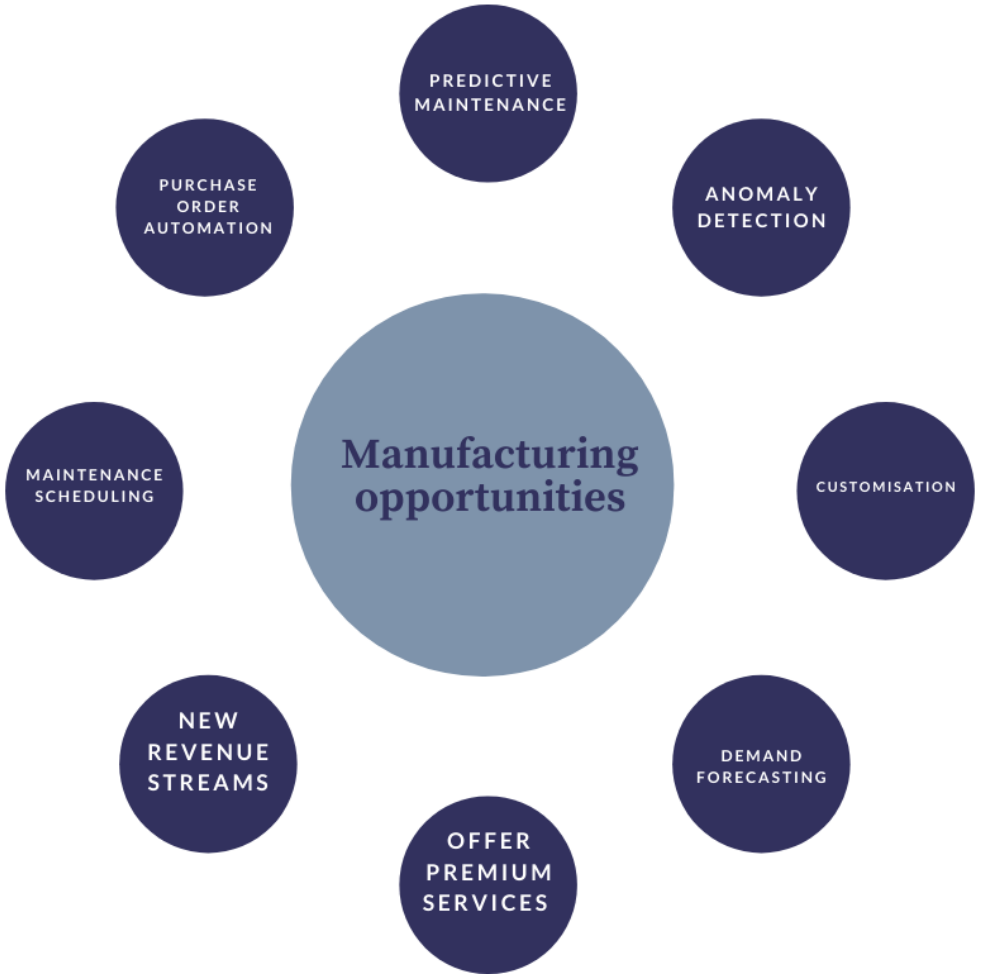
HOW BIG IS DATA SCIENCE IN MANUFACTURING?

According to one estimate by Emergen Research, "**The Big Data Analytics in Manufacturing Industry Market was valued at USD 1.11 billion in 2020 and is expected to reach USD 6.79 billion by 2027, at a CAGR of 33.1% over the forecast period 2021 - 2027**. " [2]

In another estimation, "TrendForce forecasts that the size of the global market for smart manufacturing solutions will surpass US$320 billion by 2020." In another report it was stated that "The global smart manufacturing market size is estimated to reach USD 395.24 billion by 2025, registering a CAGR of 10.7% according to a new study by Grand View Research, Inc."[3]

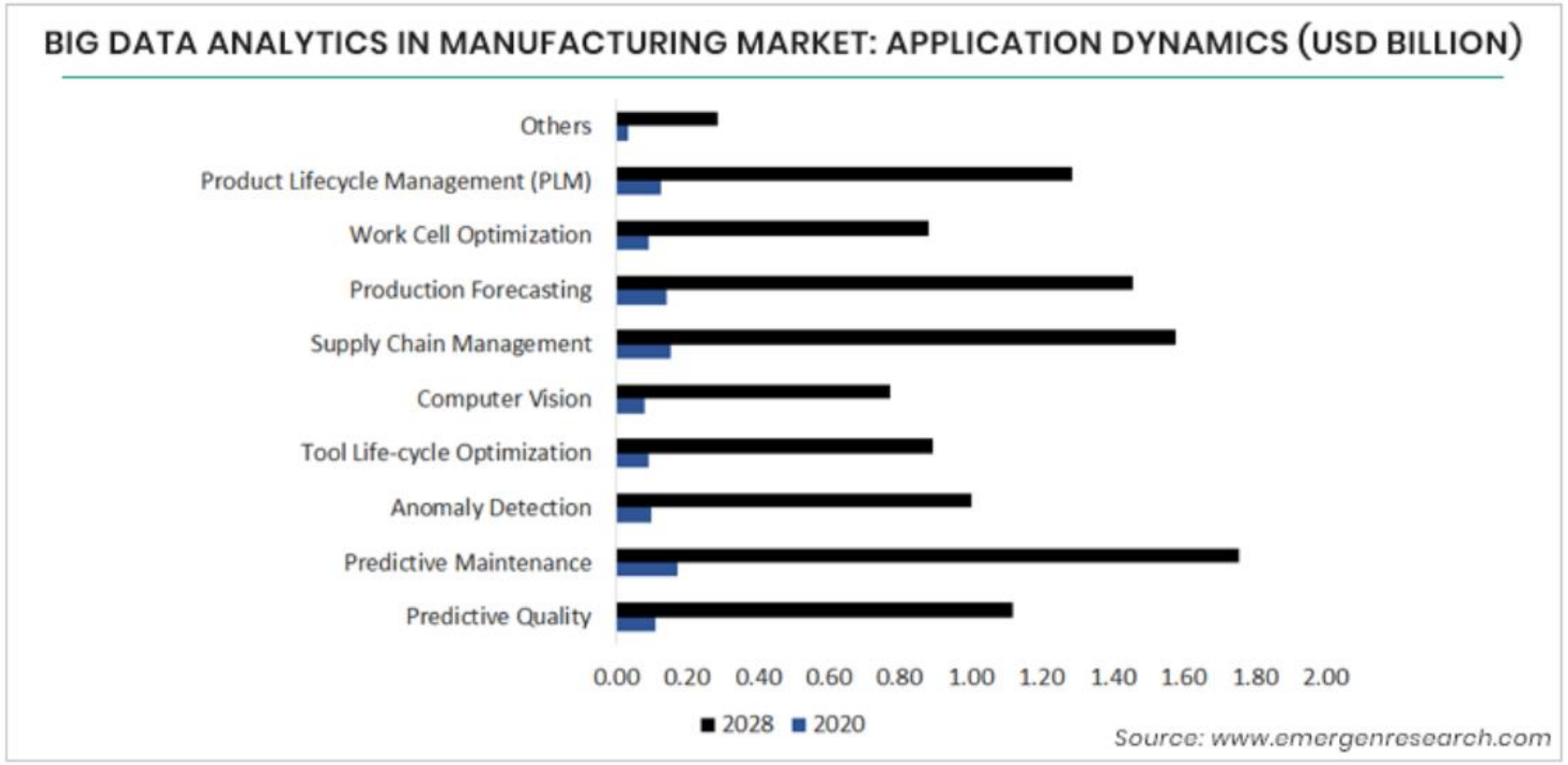
Big data analytics is a framework of gathering large volume of data for data mining, trend analysis. Over the years, industrialization is taking place at a fast pace and the volume of manufacturing is increasing day by day. Therefore, the massive shift in data generation by manufacturing industry is pushing the global big data analytics in manufacturing industry market. [4]

HOW IS DATA SCIENCE USED IN MANUFACTURING



Data science opportunities in manufacturing [5]

HOW BIG IS DATA SCIENCE IN MANUFACTURING? APPLICATIONS AND PREDICTIONS



DATA SCIENCE LIFECYCLE

Data Science Tools

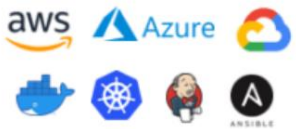
1 Languages

2 Data Analysis

3 Data Engineering

4 Web Development

5 Cloud DevOps

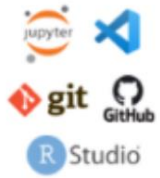


6 Machine Learning

7 Business Intelligence

8 Other

Development and version control, repositories, integrated development environments (IDE)



(Min, 2020)

Source: Min

Data Science stack for this course

1 Languages

2 Data Analysis

3 Data Engineering

4 Web Development

5 Cloud DevOps

6 Machine Learning

7 Business Intelligence

8 Other

Development and version control, repositories, integrated development environments (IDE)

(Korre, 2021)

Data Science stack for this course

REFERENCES

1. Dhar, V. (2013). "Data science and prediction". Communications of the ACM. 56 (12): 64–73. doi:10.1145/2500499. S2CID 6107147
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