The role of Artificial Intelligence in fighting the COVID-19 pandemic

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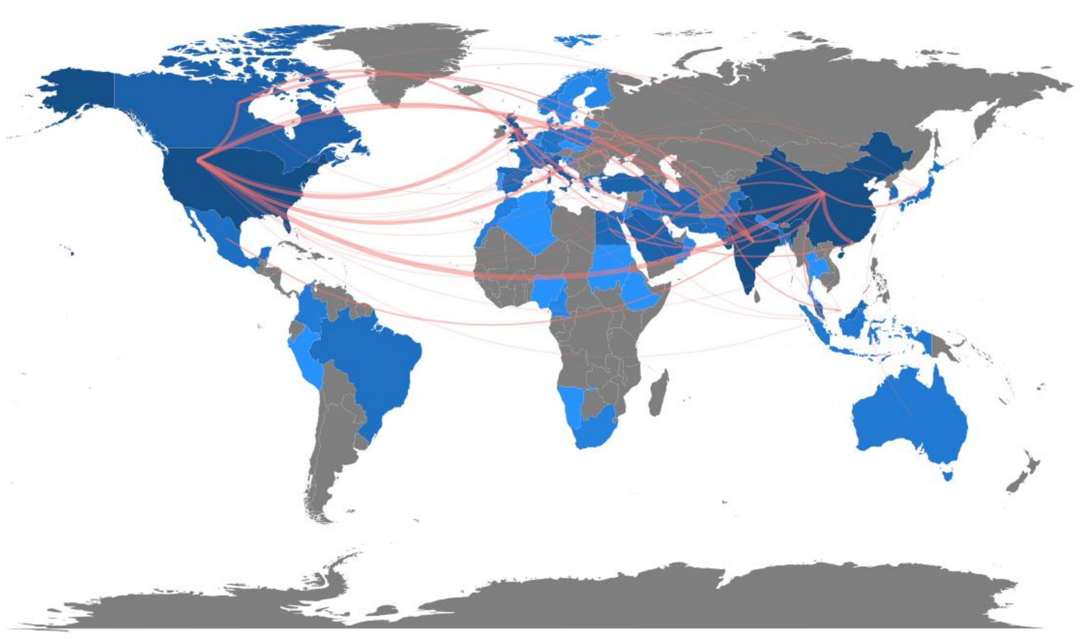
Abstract

The first few months of 2020 have profoundly changed the way we live our lives and carry out our daily activities. Although the widespread use of futuristic robotaxis and self-driving commercial vehicles has not yet become a reality, the COVID-19 pandemic has dramatically accelerated the adoption of Artificial Intelligence (AI) in different fields. We have witnessed the equivalent of two years of digital transformation compressed into just a few months. Whether it is in tracing epidemiological peaks or in transacting contactless payments, the impact of these developments has been almost immediate, and a window has opened up on what is to come. Here we analyze and discuss how AI can support us in facing the ongoing pandemic. Despite the numerous and undeniable contributions of AI, clinical trials and human skills are still required. Even if different strategies have been developed in different states worldwide, the fight against the pandemic seems to have found everywhere a valuable ally in AI, a global and open-source tool capable of providing assistance in this health emergency. A careful AI application would enable us to operate within this complex scenario involving healthcare, society and research.

The Worldwide map of scientific production related to AI and COVID-19



Thanks to the Bibliometrix[1] tool, developed by M. Aria and C. Cuccurullo, and the Scopus database, it has been possible to show that more than 1000 peer-reviewed papers containing the keywords "COVID-19" and "Artificial Intelligence" have been published from the outbreak of the epidemic to 1st March 2021.

As reported in Figure , event though, not surprisingly, most of this scientific production come from "first-world" nations, these topics have also aroused considerable interest in countries from mid-east Asia and North Africa. For instance, in states such as Iran, the COVID-19 pandemic has struck with particular strength due to a deficiency in monitoring actions and a weaker healthcare system. AI technologies, expecting to offer efficient and low-cost models to address medical and social issues, have naturally attracted many of the more seriously affected regions. Countries such as Iran, Turkey and Egypt, alongside the USA, China, India, Italy and the UK, are among the top ten states where more peer-reviewed papers related to the application of AI technologies to COVID-19 issues have been written.

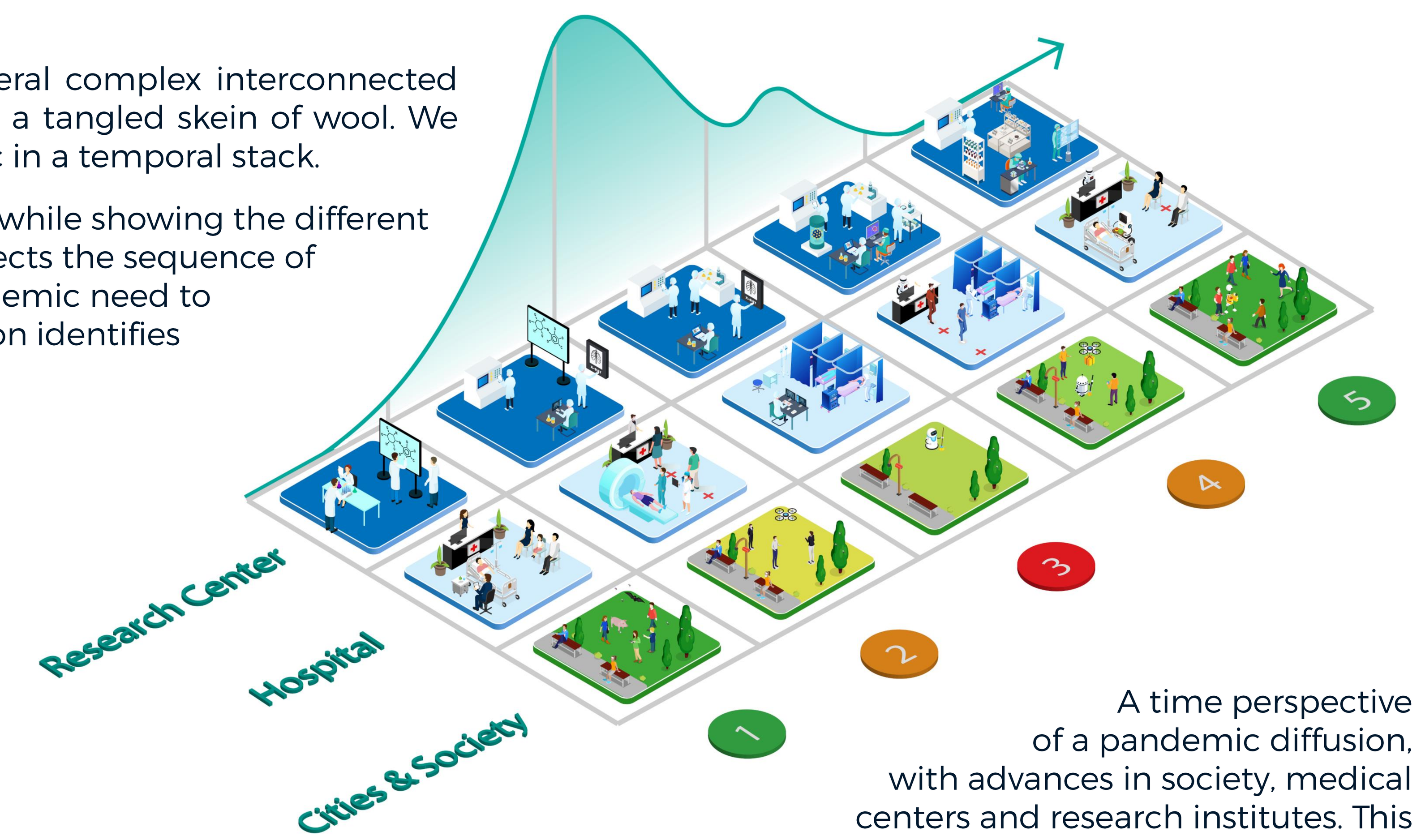
[1] https://www.bibliometrix.org/

The Pandemic Dynamics: a Conceptual Overview

The pandemic dynamics landscape is composed of several complex interconnected relations among data, models, and applications, just like a tangled skein of wool. We aim to untangle such dynamics by freezing the pandemic in a temporal stack.

The Figure illustrates the evolution in time of a pandemic while showing the different contexts and the related AI applications. The timeline reflects the sequence of decisions relating to how the different phases of the pandemic need to be addressed, according to the WHO (2009). This institution identifies six pandemic phases plus two other periods (a post-peak and a post-pandemic).

These can be grouped into five periods, according to the actions needed to betaken into account. The Figure shows data generated in different phases and areas of society.
As the clinical data is generated from patients and analyzed in laboratories, patient health records and time series are deduced from the pan-demic data and X-Ray and CT are generated in hospitals; all this data results in a range of applications that AI can enhance outbreak prediction, spread tracking, diagnosis, drug production and drug repurposing.
Technically speaking, at different stages of the pandemic spreading timeline, scientific papers report information about the data collected and cases tested to investigate the disease's characteristics.

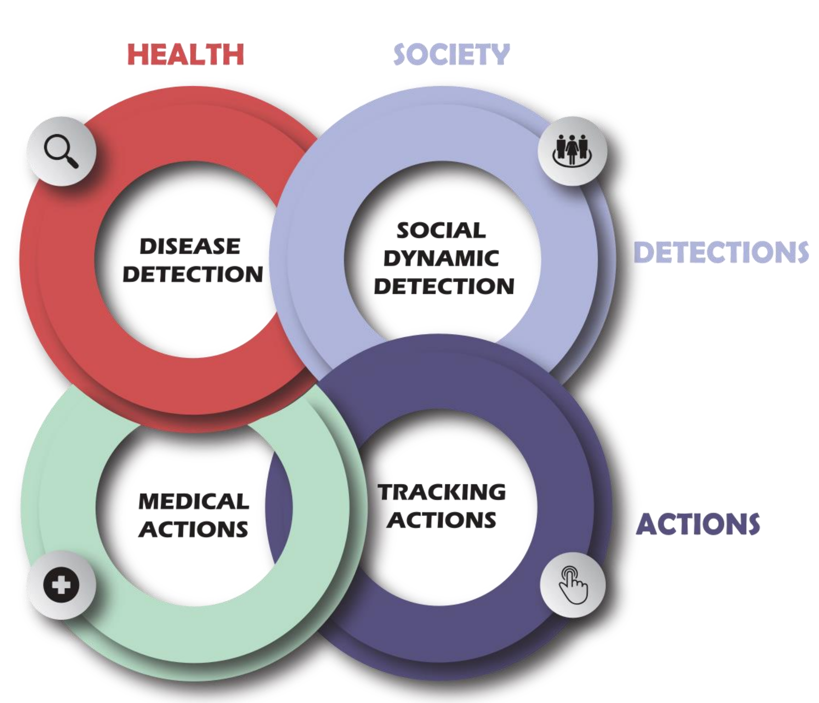


A time perspective of a pandemic diffusion, with advances in society, medical centers and research institutes. This Figure shows how the collection methodology on the type itself of data evolves in time and interwines with various areas of society. Clinical data generates health records, which, grouped in time and by population leads to time series, predicted by forecasting models to anticipate the epidemic evolution.

Where we are and What is next

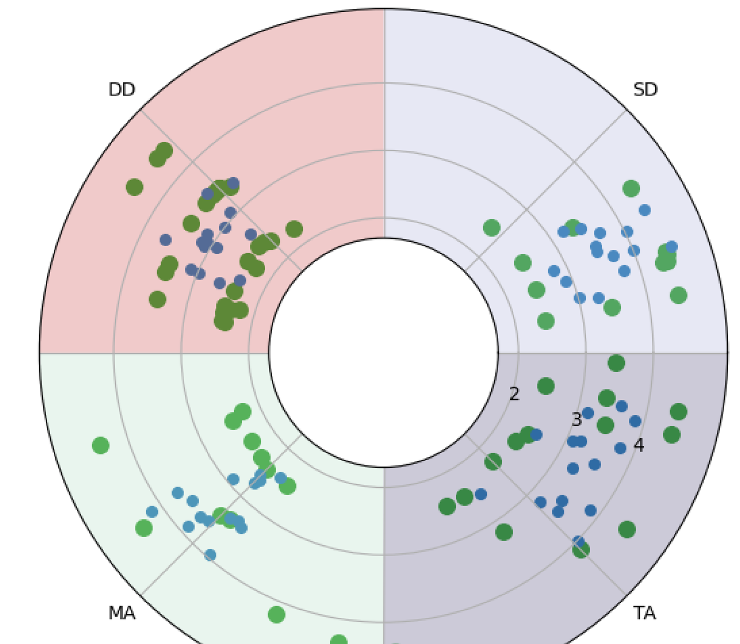
The proposed overview of scientific works published during the ongoing COVID-19 pandemic highlights some achievements and limitations of AI in tackling the 2020 pandemic.
By considering the four domains (health and society applications able to detect and act), there are still requirements that AI cannot quite attempt.
Indeed, AI still holds three well-known features which can result in potential failure: the absence of strong AI, its inability to work without knowledge of the domain, and the need for good quality and flow of data. Furthermore, ML and DL techniques must be scrutinized in order to determine what are the best current solutions, as well as future developments and research perspectives, without ignoring ethical concerns (such as trust and privacy) that currently hinder AI usage in our society.
The new society's nature, intertwined with AI after the pandemic, is fraught with problems, especially about ethical issues, such as trust, accountability, and privacy. When an algorithm fails to diagnose a health issue, what needs to be taken into account?.
Governments play a critical role in enabling AI to reveal its capacity to assist in tackling a pandemic. It is a lesson we have learned already, from the SARS epidemic in 2002.

Fields of Application



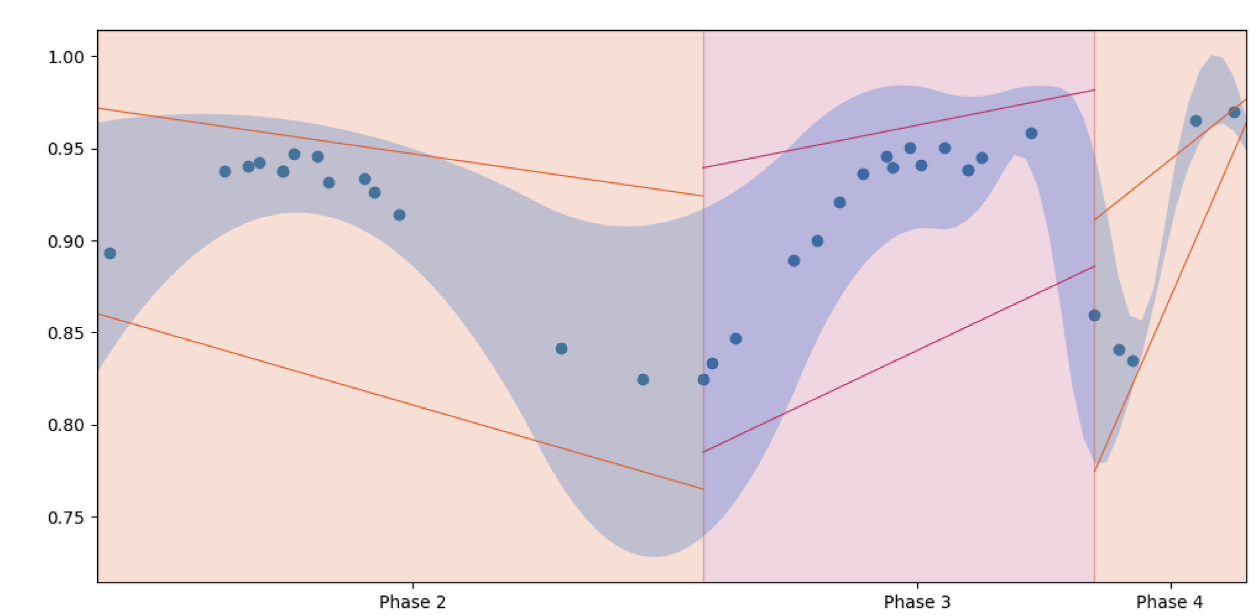
AI can be defined in terms of stages of observation and action. In the context of a pandemic, AI is applied in two main areas, namely medical research and the social context. Therefore, in order to study AI applied during a pandemic, we need to focus on four areas: disease detection (diagnosis), social dynamics observation (predictions), medical actions (treatments) and social management (tracing). Points plotted on the polar graph represent the papers in the literature. The positions deponent on how much each paper we analyzed we considered belonging to each of area, within the3central stages of the pandemic.

To better organize and explain all the possible applications during a pan-demic of AI methodologies, we divided them into four main application areas: The areas shown in Figure encompass two pillars of AI – *action* and *detection* - related to two context, namely *society* and *health*. In each temporal stage, different pandemic dynamics act on the environment, determining consequences on social behavior and healthcare status.



Machine Learning aspects

To better observe how proposed research works have improved performance in classification tasks, we plotted the Receiver Operating Characteristics Area Under the Curve (ROC-AUC)
The AUC trend shown in the Figure depicts how qualitative behaviour of published models improved during the pandemic, in terms of classification performances with respect to AUC. In Phase 2, papers mainly analyze known models on the first bench of data. The AUC decreases due to the exploration of new techniques that require a tuning step. In Phase 3, based on explorations conducted during Phase 2, models become more robust, and min a max AUC values come closer, and optimal AUC values emerge. In Phase 4, challenging models are implemented, and accuracy can easily increase since a wide spectrum of data is coming, while fine-tuning procedures have become more feasible.



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