

## **Applications of Artificial Intelligence to Fight COVID-19: Technological Prospecting based on patents**

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The COVID-19 pandemic and the consequent growth of scientific and technological research to combat it present challenges for researchers who need to keep up with the knowledge produced in this area. In this way, we carried out a technological prospection describing the technological landscape of the applications of AI in the fight against COVID-19. We adopted a descriptive methodology with quantitative and qualitative analysis of patentometric bias from data available on patents deposited in several intellectual property offices covered by the Questel Orbit Intelligence platform. We prepared the sample database using the search expression: ((ARTIFICIAL INTELLIGENCE OR MACHINE LEARNING OR DEEP LEARNING OR NEURAL NETWORK)/TI/AB/CLMS AND (COVID\_19 OR CORONA\_VIRUS OR 2019\_NCOV OR SARS\_COV\_2 'OR "MERS-COV" OR "SEVERE ACUTE RESPIRATORY SYNDROME" OR "MIDDLE EAST RESPIRATORY SYNDROME")/TI/AB/CLMS) AND APD >= 2019-12-3.

Data was collected in December 2021. Only the title (TI), abstract (AB), and claims (CLMS) fields were used to capture the technologies and their applications with greater specificity. We evaluated the time series (ST) from patent family filings around the world over the years. The year of the first deposit is the most suitable to be used, as it refers to the date closest to the conception of the technology.

We also assess the Technology Producing Centers and Protective Markets. We used for analysis: i) Technical Areas with IPC and CPC codes are the main qualification instruments of the areas to which the deposits are associated; ii) Word Cloud by title, abstract, or claims fields. To relate the predominant technological domains in the sample, we performed the analysis of the Technical Areas through the Cooperative Patent Classification codes. We analyzed 350 patent families that were organized by technological categories. An important point is that, due to the time lag between the patent application and publication, it is quite common for published patent counts to decrease in the last two years of a time series. On the other hand, the pandemic may have served as a reason for applicants to have requested the voluntary early publication of patent applications involving technologies related to the diagnosis, prevention, or treatment of COVID-19. The early publication can facilitate collaborations, partnerships or joint ventures, negotiations, and competitive advantages for various stakeholders. We identified the top country (quantitatively) in the production of technologies: India with 110 patent families, China with 94, the United States with 74, and Australia with 37. The other countries in the sample have a maximum of 10 families of patents deposited. In the case of Brazil, for example, only one patent stands out: "Spectral profile for diagnosis of COVID-19, use of it, method, system

and platform for diagnosis of COVID-19" filed jointly by Imunoscan Engenharia Molecular and Universidade Federal University of Uberlândia (UFU).

Another necessary analysis concerns the Protection Markets, that is, in what countries patent rights are still active (pending or granted). It is possible to observe the predominance of patents filed in India (31.43%), in China (26.86%), and in the United States (21,14%), in addition to PCT patents and filled at the European office – 20.57%. There is also expected to be a relationship between protection markets and countries with the highest incidence of COVID-19 cases. The countries with the highest number of COVID-19 cases are the United States, India, Brazil, the United Kingdom, and Russia (data updated on December 07, 2021). With the Questel Orbit Intelligence data from the parameters of this research, it is possible to notice the predominance of academic institutions (universities), notably Chinese. This is consistent with the findings of other studies on the same topic. Half of the works analyzed in the review conducted by Abd-Alrazaq et al. (2020) were published by institutions in China. As SARS-CoV-2 originated in China and affected it most during the first 3 months of the pandemic, it had most of the data related to COVID-19, which led to pioneering research on the topic. Thus, the collaboration between innovative countries and organizations was not noticed, unlike what was observed in academic collaborations in previous studies.

In summary, although many countries have collaborative relationships in the research or funding phase, their cooperation materialized in the ownership of patents is weak and research on COVID-19 is still carried out internally in each country. By analyzing the predominant technological domains in the sample, the top 5 of the following Word Cloud was produced: Analysis of biological materials (26) | Audiovisual technology (10) | Basic Material Chemistry (4) | Biotechnology (23) | Chemical engineering (2). The Cooperative *Patent* Classification (*CPC*) Subclasses were predominant G16H (107 patents), G06N (69 patents), A61B (59 patents), G06K (42 patents), G06T (36 patents). CPC code G16H-050 represents 30.57% of the technologies in the sample (107 patent families). This classification covers ICTs specially adapted for monitoring, detecting, or modeling epidemics or pandemics. More specifically, the CPC code G16H-050/20 also stands out with 63 classified patents. This group deals with ICTs specially adapted for medical diagnosis or computer-aided diagnosis, eg. based on specialized medical systems. It is also worth mentioning the CPC code G16H-050/80 with 54 families of classified patents, it addresses the ICTs used to monitor, detect or model epidemics or pandemics, for example for alerts on influenza, Ebola, HIV, or even bioterrorism. We also verified the predominance of technologies in the areas of computing and medicine, that is, Information and communication technologies (ICT) adapted for the treatment or processing of medical data with a focus on identification, screening, diagnosis and prediction of new outbreaks of an epidemic. Although this work specifically explored the use of AI against COVID-19, some applications analyzed may be useful after the pandemic. From the consideration that the world health system needs new technology support systems, such as AI, Internet of Things (IoT), and machine learning devices to help diagnose, analyze, assist and prevent new diseases that are spreading in the world, it has been found that AI technologies have been introduced to help with patient management, real-time monitoring of their outbreaks

and helping to update patient data, improve treatment outcome by prioritizing patients, diagnosis, assisting physicians and providing better solutions.