

Mapping of technologies using thermal images to control epidemics

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Abstract

The quest to combat the spread of the new Corona Virus Pandemic is a battle experienced worldwide, more specifically in the year 2020 when it caused a tragedy in the lives of a large part of the world population. The current numbers of contaminated people and deaths are alarming. Transmitted through droplets expelled through the nose or mouth, it leads to fever, which is the most common symptom of COVID-19. A technique that uses thermal images to check dispersed heat is a thermography. These images are captured by thermal cameras or devices with temperature sensors. Thus, the purpose of this work was to map the deposits of patent applications in order to seek technologies related to the use of thermal images to control the pandemic. The search base chosen for this research characterized as exploratory quantitative was Espacenet, which returned a final result of 119 published patent documents. Of these 93 documents were worked on in this article which gave us a more discussed result, since the others were repeated. The research revealed that patent applications in this area were stable until the current year when a Corona Virus pandemic spread, forcing researchers to develop research in order to combat it. The increase in the number of patents in 2020 shows the tendency to increase to 2021 when new research should appear and, consequently, new patented documents may be exposed in the future.

Keywords: pandemic; corona virus; patents; thermal images;

1. Introduction

It is visible worldwide that countries are looking for ways to prevent the spread of the new Corona Virus Pandemic. (ALJAZEERA, 2020). According to the World Health Organization - WHO (2020), until September 14, 2020, the global panorama is 28,918,900 confirmed cases and 922,252 deaths. The highest incidence of confirmed cases is registered in the American continent, representing 51.23% with 14,815,178 of the total of these cases. The American continent also outperforms the others in terms of the number of deaths, representing 55.45% with 511,427 deaths. Brazil records 4,315,687 confirmed cases (14.92%), occupying the third place and classified, as for transmission as community. Regarding the number of deaths, Brazil ranks second with 131,210 deaths, representing 14.23% of the total deaths.

COVID-19 is a virus, as are Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS). Fever is one of the most common symptoms of COVID-19. The disease is transmitted to people through the droplets that are expelled through the nose or mouth, when speaking, coughing or sneezing. Another form of contagion is by touching a surface that contains these particles and then touching your eyes, nose or mouth (WORLD HEALTH ORGANIZATION, 2003).

According to ANSER et al. (2020), communicable diseases affect poor and rich nations, requiring the adoption of preventive measures. The lack of basic services in certain regions of poor countries increases the transmission of these diseases, as well as the lack of information about security measures to combat contagion.

Thermography is a technique that uses thermal images captured by thermal cameras or devices with temperature sensors, allowing to verify the dispersed heat (SHARMA; YADAV, 2017).

There are several ways to perform the measurement in order to result in different results. The most common clinical investigation is the measurement of temperature. An ideal thermometer should perform the measurement accurately, making it possible to obtain the result quickly, ensuring safety and absence of potential risks (KOCOGLU et al., 2002).

According to LIU; CHANG; CHANG (2004), several countries used techniques to identify people who had fever as a way to contain the spread of severe acute respiratory syndrome (SARS), which occurred in 2003. In Taiwan, some safety measures were applied, such as measuring the temperature of all people entering or leaving the country. At strategic points such as airports, hospitals, schools, government facilities, and large confined spaces, screening was put in place to measure people's temperature and allow them to enter these places.

Due to the high number of people to measure the temperature, the method that was chosen in Taiwan was the use of the infrared thermometer that measures the temperature by the body surface of the forehead, but that is not the most reliable way. The most efficient way of measuring is through the ear canal. According to SIMÕES; MARTINO (2007), to measure the auditory canal, tympanic thermometers are used whose working principle is based on the measurement of the amount of infrared energy emitted by the tympanic membrane and nearby tissues. According to LIU; CHANG; CHANG (2004), the external environmental factors alter the temperature in the body, decreasing the precision of the values obtained from the forehead temperature.

According to ZHANG et al. (2020), the temperature measurement technology with the use of thermal images developed quickly because it has some advantages, such as the possibility of carrying out the measurement at a long distance without the need for contact and allowing the accomplishment of several measurements at the same time with precision. Some factors such as ambient temperature, lens temperature, detector temperature and other factors interfere with the accuracy of the temperature measurement, but the most important factor is the high precision calibration performed on the equipment.

According to KUMAR et al., (2018), the Internet of things (IOT) allowed devices through the use of sensors "devices or things" to detect data that will be processed by other devices or things, being connected via the internet. These devices can be used to detect health changes. Learning algorithms are used to process the large amount of data and to make the decision.

The use of thermal imaging technology to monitor body temperature has the advantage of reducing the risk of infection for operators and eliminating the inefficiency of manual measurement (YOUXI; GUOKUN, 2020).

According to JIANBO et al. (2020), the temperature screening carried out in places where there is a large flow of people is carried out by a measurement mode that, although it is non-contact, the efficiency is low due to having to measure one person at a time. This method comprises a measuring gun with an infrared

measuring system.

The temperature measurement based on facial recognition allows the control of authorized persons access and the control of epidemics by issuing a warning in cases of high temperature detection. In this way, it is possible to allow only people with the temperature at the acceptable limit. This system can be applied in public places where there is a large flow of people such as transport stations, parks, schools etc. This measure prevents the spread of the virus (GUANGBIN, 2020).

Therefore, this study aims to investigate the technological production related to the use of thermal images to control the pandemic through the use of the mapping technique based on patent searches using the Espacenet platform and then carry out an analysis of the temporal behavior regarding the number of publications in the period chosen for analysis, which was since 2002 when the first patent on the topic was published.

2. Theoretical Foundation

The use of thermal images is an efficient way to identify cases of Covid-19 in environments that require a large flow of people. The traditional method of individual verification with the non-contact thermometer puts the operator at risk and takes a long time to verify a crowd of people (P RANE, 2020). According to MAGESH et al. (2020), thermal cameras detect radiation producing thermal images, being able to detect the temperature of several people in a few seconds.

In 2003 the first case of Severe Acute Respiratory Syndrome (SARS) was reported in China, which is a disease caused by the SARS-CoV corona virus. Spreading rapidly to other countries before the outbreak was contained (CENTER FOR DISEASE CONTROL, 2013). According to NEGISHI et al. (2020), in December 2019 in the city of Wuhan in China the first case of Covid-19 occurred and spread to more than 110 countries in March 2020. It is necessary to implement systems for measuring multiple vital signs in places where there is a concentration of people.

A sorting system can have one or more sorting stations. At airports, these systems use a combination of questionnaires, trained observers and screening devices in order to detect travelers who carry an infectious agent. If there is any suspicion, travelers are subjected to laboratory tests to prove it. Once the suspicion is confirmed, they are referred for treatment. To choose the screening system to be adopted, one must know the clinical manifestations of the infectious disease to prevent the spread of infectious agents (GOLD et al., 2019).

According to GOLD et al. (2019), the most efficient way to identify infected people is to search for the most frequent symptoms of the disease. According to NEGISHI et al. (2020), most infectious diseases have temperature, heart rate and high respiratory rate.

If resources for screening at airports are limited, you must first install screening at departure terminals at airports located in affected countries. But to increase the detection rate, sorting systems must be installed at the Arrivals terminals (GOLD et al., 2019).

According to NGUYEN et al. (2010), some infrared thermal detection systems have automatic calibration adjusting to environmental conditions. But there are thermal detection systems that need to be manually calibrated for the environmental conditions of the site, which influence the measurement results of both

thermal measurement systems and oral measurement systems.

The success in avoiding transmissibility is related to the identification of cases quickly. (FERGUSON et al., 2005) According to VILKE et al. (2020), many companies are using temperature measurement screening to allow customers and employees to enter.

According to JIANG; HU; ZHAI (2020), the first symptom presented by a person infected with Covid-19 may not be fever. Thus, devices that use only the measurement of body temperature as a parameter would not be effective because it disregards the other initial symptoms. It is necessary to evaluate multiple symptoms by the device to improve the effectiveness of the screening. Another parameter that can be increased in the analysis by thermal cameras is the respiratory state simultaneously with body temperature, which is more used in the screenings than the assessment of the respiratory state. Breathing is the most important parameter for the analysis of vital signs and it is possible to use thermal images to perform the analysis of the breathing pattern and frequency. The use of thermal cameras allows facial recognition if the person is wearing a mask and with the use of algorithms it is possible to analyze the information regarding temperature and breathing status. According to BUOITE STELLA et al. (2020), due to the large number of asymptomatic people and people who do not have a fever even though they are infected with Covid-19, temperature measurement cannot be considered as the only safety protocol. Needing to measure other physiological parameters using different devices and creating algorithms capable of performing the analyzes.

According to technology developed by SOMBOONKAEW et al. (2020), the use of internal temperature compensation and external temperature was able to provide promising precision results for technologies that use thermal cameras. Efficiency is another point that favors technology for application in high-flow site screening, this technology being able to detect the temperature of 9 people at a speed of 8 frames per second, with an accuracy of 92.7%.

According to BUOITE STELLA et al. (2020), the use of the infrared thermometer is not necessary as it may have measurement variations due to the distance from the thermometer in relation to the body location, the location of the face chosen to make the measurement is another point that influences the accuracy, as depending from the location chosen to perform the measurement, different values can be obtained. The temperature measured on the forehead does not represent the best measurement location because it does not represent the central body temperature. To improve the accuracy for these types of thermometer it is of utmost importance that those responsible for measuring the temperature receive training from the manufacturer.

Using only fever as the only parameter in the screening is not feasible, as a false negative can be presented due to the use of antipyretic drugs to control fever. Thus, the use of thermal cameras is not sufficient to detect cases of febrile influenza (NISHIURA; KAMIYA, 2011).

According to SILAWAN et al. (2018), to perform mass temperature monitoring the most viable technology is the use of thermal cameras that have the possibility of measuring the temperature of several people in a large area, but the performance still needs to be improved. To improve the accuracy, it is possible to perform a measurement of several points on the face using thermal image capture and perform an estimate by correcting these different temperatures. Thermal cameras prevent people from having to stop at test stations. The capture of the temperature of multiple facial areas does not lead to a substantial increase in processing

time that compromises the advantage of the speed of temperature measurement performed by thermal cameras in relation to other methods of measurement.

Since 2003, after the SARS outbreak, many airports have used thermography to measure the temperature of many people. The same method remained for more than a decade, but according to the system proposed by NAKAYAMA et al., (2015), thermography can also be used to monitor respiratory and cardiac alternations generated by infection.

3. Methodology

The methodological scope of the research was restricted to selecting and investigating technological production related to the use of thermal images to control the pandemic. The ESPACENET patent search base was used as an information source, which is a free online service for searching for patents and patent applications developed by the European Patent Office (EPO) in conjunction with the member states of the European Patent Organization.

The survey of technological production on the ESPACENET base was carried out in September 2020, selecting the field Patent search, and using as keywords the following combinations shown in Table 1:

Table 1: Combinations of keywords for patent search

(ctxt = "thermographic" OR ctxt = "thermal") AND (ctxt = "human" OR ctxt = "person") AND (ftxt any "Epidemic" OR ftxt any "SARS" OR ftxt any "coronavirus") AND (ctxt any "temperature" OR ctxt any "fever") AND (ctxt any "imaging" OR ctxt any "camera")
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Source: Prepared by the authors based on the Espacenet search database (2020)

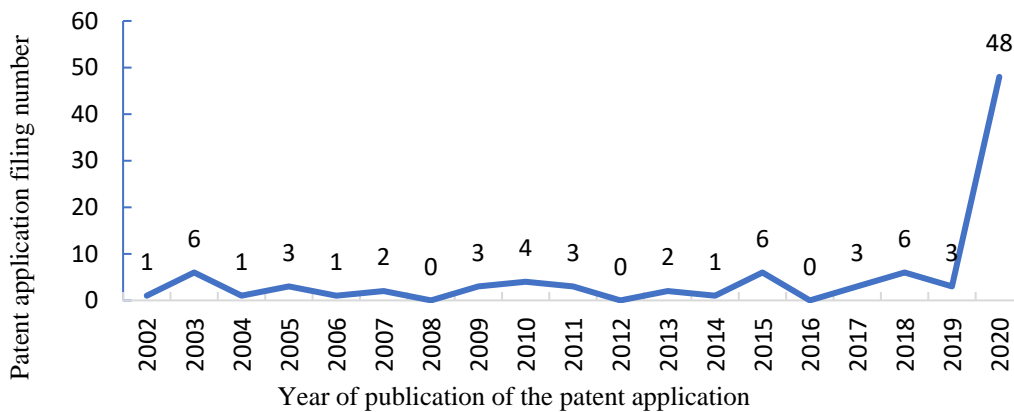
The search resulted in 119 patent documents published from 2002 to 2020. Subsequently, an analysis of each patent was carried out and 25 of them were discarded because they were not related to the purpose of this study. Then, the data were grouped and processed in order to obtain the following information: number of publications per year, patent applications by country of origin of the technology, IPC classifications with higher occurrence in the applications and number of patents published by the inventor.

4. Analysis and discussion of results

After data collection, the first analysis to be carried out was the distribution of patents related to the use of thermal images to control the pandemic per year, as shown in Figure 1. Next, patent applications by country of analysis were analyzed. origin of the technology (Figure 2) in order to be able to verify which country obtained the highest number of requests on the topic. The search ends with the IPC classifications with the highest number of occurrences in the applications (Figure 3) and the number of patents published by the inventor on the study under analysis (Figure 4).

It is worth mentioning that both results show a series of quantitative variables. Thus, we chose to work with the most expressive, with the exception of Figure 1, which is the presentation of the series of patent distribution data related to the theme per year during the period under analysis.

Figure 1 - Distribution of patents by year

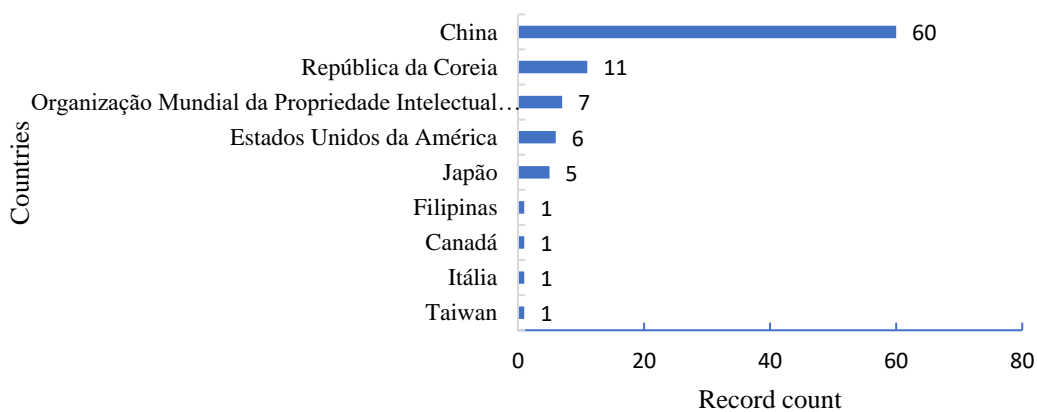


Source: Prepared by the authors, using data collected in Espacenet (2020)

Figure 1 shows the annual evolution of patents on technologies related to the use of thermal images to control the pandemic based on the Espacenet platform. The research took the period from 2002 to 2020. The evolution shows a stability in the number of patents until the year 2019. It is visible that in 2020 the number had a sharp growth, going from 3 patents in the previous year to 48 patents (2020) related to the technologies of using thermal images to control the pandemic. This fact can be justified by the scenario that the world is experiencing in relation to the pandemic of the new Corona Virus - COVID19.

It is important to state that the year is still in progress, that is, new patents may be registered or even those that are under confidentiality may be disclosed in the following months. Thus, the stability seen until the year 2019, which was with values ranging from one to six patents, will probably no longer occur in later years.

Figure 2- Patent applications by country of origin of the technology

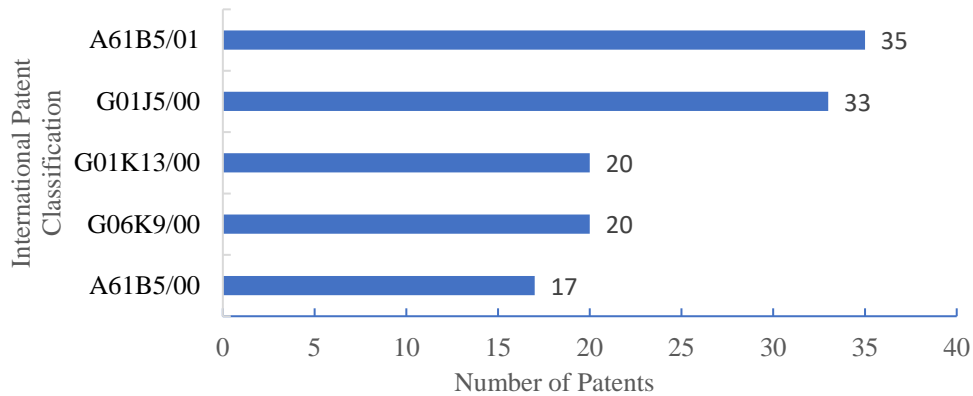


Source: Prepared by the authors, using data collected in Espacenet (2020)

Figure 2 highlights that there is a concentration of patent applications in China followed by the Republic of Korea. We noticed, through the graphical visualization, that the difference between these two countries, in relation to the number of patent applications, is quite significant, that is, China is far ahead in the requests based on the researched theme.

In four countries (Philippines, Canada, Italy and Taiwan) the numbers are equivalent, that is, only one patent application on technologies related to the use of thermal images to control the pandemic was registered in the search base.

Figure 3 - IPC classifications with higher occurrence in orders

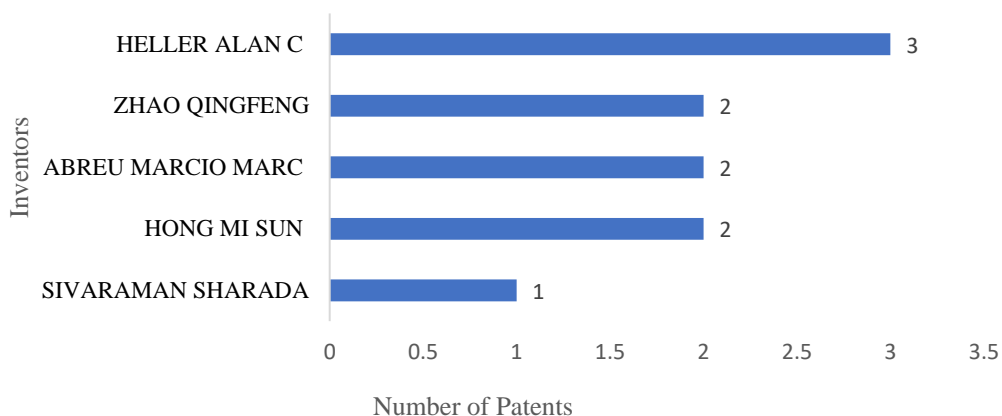


Source: Prepared by the authors, using data collected in Espacenet (2020)

Figure 3 shows the codes of the International Patent Classification (CIP), which aims to organize patent documents, in order to facilitate access to the technological and legal information contained in these documents (INPI, 2020). The five classifications that presented the largest number of documents were separated.

The deposits found are mostly allocated to classification A61B5 / 01 with 35 patents, followed by classification G01J5 / 00 with 33 patents. Analyzing all classifications, it is noted that section G (Physics) presented the highest number of patents (58.4%) followed by section A (Human Needs) representing the complement of the number of patents (41.6%).

Figure 4 - Number of patents published per inventor



Source: Prepared by the authors, using data collected in Espacenet (2020)

Figure 4 shows the inventors who have the highest number of patent filings on the subject under analysis. The inventor Heller Alan C. was the one who filed more patents among the five most researchers with a

total of three patents. The rest had two and one deposits, respectively.

It is appropriate to justify that the other inventors have the same amount of patent filings as the inventor Sivaraman Sharada and so it was decided to work with the first five, since from the sixth inventor onwards, the number of patents filed was only one patent.

5. Conclusion

In the research addressed, a patent search was carried out on the Espacenet platform with the purpose of verifying the number of patents on technologies related to the use of thermal images to control the pandemic. This fact made it possible to note that technological studies were being carried out in an unstable manner based on the results found, that is, the number of patent applications was not higher than six annual deposits. With this search, it was possible to notice the need for research related to the theme, since there was a need to control the number of deaths before the new COVID19 as a result of the high number of infected people that this pandemic moment caused worldwide. This fact was confirmed by the significant increase in patent filings on the subject when it went from three patents in 2019 to 48 patents in 2020.

Therefore, the mapping technique is of fundamental importance to check how is the technological production scenario around a certain theme that you want to study. With this, it was possible to prove that research on technologies related to the use of thermal images to control the pandemic tends to increase in later years, given the circumstances experienced worldwide, especially from the end of 2019 with the new pandemic Corona Virus.

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