Engineering Solutions 4.0 in the fight against the spread of Covid 19

A new Methodology including processes, procedures and devices

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Abstract: Thanks to the principles and technologies made available by Industry 4.0, the authors conceptualized and modeled a new strategy, capable of making an effective contribution to the problem of limiting contagion from Covid19 today, and tomorrow from any possible other type virus, bacteria or pathogen agent introduced by subjects who, although unaware of being vectors, develop the infection only after their access to the places of stay (Hotel, office, Infrastructure, etc.) where they go to reside. The key point of the strategy is a 4.0 thermoscanner, created by the authors, which is positioned in appropriately chosen locations of the settlement and an innovative method of disinfection of the same implemented by means of UV-C rays and Ozone in the gaseous state, produced by a machine, also conceptualized and developed by the authors, capable of reproducing the Chapman Cycle with the associated advantages. Therefore, it is operated an absolute disinfection based on a reversible cycle Oxygen-Ozone-Oxygen, with a prompt re-habitability of the treated rooms, with minimal treatment costs and without the use of expensive and unhealthy chemicals or wet water vapor (incompatible with paper and electronics). This technology was described in the paper "Sanitizing of Confined Spaces Using Gaseous Ozone Produced by 4.0 Machines" presented by the authors to the WCE 2021 IAENG Congress and awarded with the "Best Paper Award of the 2021 International Conference of Systems Biology and Bioengineering". In the presence of a Person with a fever, the thermoscanner automatically launches an alert to the site Safety officers, who confine him to an isolated place and make the Health Institutions intervene and take it over.

Keywords: Thermoscanner, termoscanner, surface disinfection, surfacte sanitation

I. Introduction

The study was launched with a careful analysis of the literature relating to the pandemic phenomena that have affected various areas of the planet in the last century. From this analysis, the team learned that the onset of fever in subjects affected by the various viruses was almost a constant independent of the type of virus. So, it was for yellow fever as for SARS and, currently, for Covid19. Starting from this assumption and considering that such an event may recur in the future for other types of viruses, the proposing team considered as a fundamental duty to dedicate part of the research to make an effective contribution to the recognition of symptomatically infected subjects in order to avoid that They, coming into contact with other people without the necessary precautions, are vehicles of the contagion. The study presented in this paper is an emblematic case of how, in the face of particularly complex situations, researchers from different scientific backgrounds can obtain significant results by pooling their individual skills. Current example is the fight against the corona Virus and in the future against who knows what other virus or bacteria or mold; a fight that must, in fact, be faced on several fronts. Primarily it is necessary to treat the affected Patients through drugs and lung therapies, then to prevent further spread of the infection. While the treatment is certainly within the competence of the doctors, the limitation of the spread of the infection can be addressed and drastically limited with principles and methodologies typical of other disciplines such as, for example, Engineering 4.0. In this perspective, the authors of the paper focused on the aspects related to the spread of the infection, focusing initially on the problem of recognizing symptomatic people affected by the virus who need to enter highly frequented places, and subsequently also on sanitation of paths, clothing and environments through highly effective innovative systems, as well as on monitored and controlled social distancing.

II. Premise

The Italian Premier Mr. Conte announced on 26 April 2020 the start of a phase of easing the anti Covid19 measures, a phase in which he considered essential that, as a precaution, all the stations of any means of passenger transport as well as places with high crowding such as supermarkets, banks, stadiums, etc. were equipped with flow adjustment turnstiles and that each person entering was subjected to a thermoscanner to detect body temperature. The idea, in itself more than

correct, on the other hand has some objective limitations. Meanwhile, the measurement with the thermometer must be carried out individually by an employee and therefore the evaluation of a large group requires a considerable amount of time with the consequence that the possible contact between people, and therefore of contagion, could constitute a significant risk. For this reason, the team has developed a column thermoscanner system combined with the access turnstile suitable for this type of need. The thermoscanner is also able to recognize that the prescribed mask is being worn and that it is correctly used, i.e. total coverage of the mouth and nose (contrary, since the virus is transmitted aerobically, the mask would be completely useless); the system notes that the person does not try to hide the part of the face dedicated to the mask with his hand; it makes sure that gloves, where required, are worn by the person passing through the turnstile and measures the correct temperature regardless of the color of the skin. In the event of non-compliance, even partial, with these requirements a local alert is sent by a siren and a notification is sent via IOT to the operations center for the necessary measures. Please note that the system acts in full respect of privacy as it does not record personal or biometrics data. It is also equipped with a web portal for monitoring and managing geo-localized alerts and reporting them to security staff. The type of solution proposed therefore aims to respond to the need to provide an effective and efficient and affordable solution to the problem of the spread of the virus in crowded environments. The research group had evaluated among the possible solutions to use suitable thermal imaging cameras to carry out a mass screening. This type of solution, which appeared to be technically valid for monitoring the temperature of each individual participant in a group, on the other hand has costs of the order of 30 thousand euros (for each thermal camera), an unsustainable expense for its widespread diffusion. Consequently, the research group with great pragmatism focused on the possibilities offered by targeted applications deriving from Engineering 4.0. The study conducted led to the development of:

- A methodology capable of addressing the problem of the spread of pathogens based on processes, procedures and tools;
- "Thermoscanner 4.0" device was derived; it represents a solution capable, at a relatively low cost (less than a fifteenth of the amount reported above), of giving an effective and efficient response to the problem of access to confined places by symptomatic people;
- Professional machines for sanitizing with gaseous Ozone and UVC rays.

III. The work team

The operative team is made up of highly qualified Partners to ensure the presence of all the skills necessary for carrying out the project. In particular, the conceptualization was carried out by the Researchers of DIME (University of Genoa, Polo di Savona, Prof. Ing. Roberto Revetria, Prof. Ing. Marco Mosca), the research and design by the Technological Partner TCore (Prof. Ing. Fabio Currò) and the development by the Technological Partner mcGEAR (Prof. Ing. Fabio Currò, Prof. Em. Roberto Mosca), the dissemination and technology transfer to companies from the Partner Consulting GDR (Spin Off Unige).

IV. Literature review

Historically, humanity has been hit by multiple epidemics, as recalled by the 2020 article [24], from the black plague that killed about 50% of the European Population in the Middle Ages, up to Spanish flu of the first half of the last century, which caused millions of deaths. Over the last century there have been many diseases that have spread around the world and have, among other symptoms, fever. coronavirus SARS-CoV-2, responsible for the COVID-19 syndrome, is no exception. As INAIL (National Institute for Accident Insurance at Work) explains in the 2020 article [25], this virus causes an infection respiratory disease whose onset symptoms typically include fever above 37.5 ° C, cough, muscle aches and pulmonary complications. A similar syndrome, as the name suggests, is SARS, which from 2002 to 2003 forced many States to start adopting measures to control entry at borders, in order to stop infections. In the two-year period 2009 and 2010, the H1N1 virus, called "swine flu", spread around the world. Already in the early stages of the pandemic, some States have adopted systems to reduce the spread of the virus. The article [26] deals with how Japan has taken countermeasures since the early stages of the pandemic regarding access to international airports. In addition, a quarantine has also been introduced, at home or in hotels. The main preventive systems, universally recognized, are the thermoscanners, which allow to understand, from a distance, if an individual is a positive suspect. The scientific journal [27] indicates the adoption of thermoscanners or infrared thermometers as a preventive and protective measure. With regard to Retirement Homes (Residences for the Elders), the "City of Sondrio Rest Home" published an organizational plan at the end of 2020 which provides, in addition to a series of internal procedures, for the provision of thermal scanners. In particular, one is placed in the main entrance and one in another entrance, in order to measure the body temperature of Those who enter the Structure. If a temperature greater than or equal to 37.5°C is detected, the entrance door remains closed and a new measurement is performed one minute later. In case of further measurement of the temperature above 37.5 °, the Individual is required to go straight back home and contact the competent doctor. It therefore becomes clear how an IoT system capable of detecting the temperature linked to facial recognition allows in charged operators to immediately have information on Who is positive and to automatically

contact the competent authorities. Obviously, as pointed out by the Nursing Home in question, it is necessary to collect preliminarily employees and guests' signatures on the documents for the processing personal data, in order to guarantee privacy. INAIL (previously mentioned institution), in the article cited above, explains how important it is to measure body temperature, using a thermoscanner since traditional methods with thermometers involve physical contact, which must obviously be avoided, require a lot of time and depend on the skills of the operator in charged. Most of the articles deal with precise measurements of body temperature carried out at the entrances to the Facilities. However, diseases have an incubation period during which the Individual is still asymptomatic. This generates the problem of giving free access to people who will manifest the symptoms only at a later time, when they are already in the Structure. This issue was acknowledged in the 2012 article [28] relating to swine fever. The authors, in fact, explain that it is impossible to completely prevent an entry into the boundaries of Positives and that a tracking system would be needed to monitor the health status of subjects who could develop symptoms of the disease later. For this reason, positive or suspicious subjects are monitored by telephone, they are in fact asked to measure their own fever in the morning and in the evening in order to evaluate improvements and worsening. This monitoring was also carried out in Italy by the employees of the ASL. This procedure, however, requires Staff dedicated to this task (Personnel increase) and therefore higher costs, also as regards the training of employees. Therefore, an automatic monitoring system that detects the temperatures of people without having to necessarily intervene Public employees or the Host Structure becomes much more efficient.

V. The Proposed Methodology

The proposed methodology was divided into two phases:

- The first relating to the monitoring of subjects who entered without showing symptoms inside the Facilities, then becoming positive for fever during their stay;
- The second relating to the sanitization of the Structures both at a preventive level and in cases of found positive fever.

The methodology consists in the implementation of clear processes and strict procedures to be followed within any Structure, as Hotels, Healthcare Facilities and offices.

VI. Step 1: Thermoscanner 4.0

Figures 1 and figure 2 illustrate the characteristics of the thermoscanner and how it works in combination with the turnstile, while figure 3 highlights the anti Covid access path devised by the team, a particularly suitable path for blocking people coming from suspicious places and confining them before can spread the virus.

Fig. 1. Mask and gloves control, color code

Fig. 2. Thermoscanner controls on User interface

A. Impact of dissemination on statistical opportunities

The thermoscanner is receiving widespread approval from security officers who, consequently, are equipping the sites with such equipment exclusively. In some time it will be also possible to have important information on the spread of the infection among people entering the confined sites, as well as to reach a limitation of the same, in accordance to the path described in the previous paragraph.

Finally, it is of great importance to remember how in a globalized world the risk of pandemics is dramatically frequent and repetitive, so it will become essential to always keep the thermoscanners active in strategic points such as passenger arrival stations from other areas of the planet, to be able to block virus carriers immediately before they can become an unstoppable vehicle of contagion as happened with Covid in Italy, in Lombardy Region.

B. Technology adopted

The temperature is detected on the forehead of the subject in transit by a Digi-key temperature sensor certified for medical use, with an accuracy level of 0.2 ° C in the range 36 ° - 38 ° C. Of particular interest is the feature that the project team considered fundamental for the apparatus such as facial recognition, to be used exclusively to identify the hill Person in case of contagion and not to monitor people attitudes or paths. In order to avoid gatherings around the apparatus, it was operated in such a way as to obtain recognition at a medium distance (50 cm). The viewing angle of the temperature sensor is restricted to 10 ° for better detection accuracy. The 316L stainless steel structure was selected and designed to have better resistance to pressure and shocks and also allows for the possibility of systematic sanitization with suitable liquids (hydrogen peroxide, sodium hypochlorite and alcohol-based substances). The software was completely developed in house both for better integration with the proprietary hardware and also to be capable to follow the possible evolution of regulations. Since the thermoscanner was designed according to the philosophies of Industry 4.0, it is interesting to highlight some aspects such as interfacing with external systems (for signaling on servers), autonomous operation or data network (LAN and WiFi), compatibility with IoT turnstiles. In addition, some more features considered to be of particular importance on an Operational level have been set up, such as: integration with people counting system in and out and an acoustic alarm.

C. Innovation compared to the most common market systems

Among the characteristics described in this paper, some constructive choices emerge, such as to differentiate the system from those commonly present on the market, including:

- The use of a particularly precise sensor in detecting body temperature even in critical conditions such as, by way of example, backlight, sweat, skin color, rain, etc. (this medical sensor was identified through a careful multi sectoral market research);
- the materials selected for the construction of a device housing capable of functioning in any environment (impact resistant and impermeable to dust and humidity);
- the materials selected for the construction of a strong and easily sanitized column;
- the versatility of use for other important security applications (to limit access of people to the numbers required by law and by the rules on distancing) and commercial (statistical surveys), such as people counter;
- facial recognition for the identification of the hill Person and its confinement awaiting rescue and, in other cases, the prevention of crime (theft, robbery or assault).

In addition to the characteristics purely attributable to the choices of hardware and software design, the device is accompanied by ad hoc use processes, dependent on the sector of use, with the aim of maximizing the impact generated by the thermoscanner (e.g. the hotel case study reported above), with clear procedures to be respected, easily manageable by appropriately trained Staff and Customers. This is also thanks to the training offered and the project documentation, which includes instructions and forms to be signed by the guests of the Structure.

VII. Step 2: Sanitization

The procedure devised by the authors obviously requires that once the infected subject has been isolated, a careful sanitation of the places frequented by the Same is carried out (room, corridors, offices, public areas), implemented by using the 4.0 machine designed and developed by the authors and described in the paper by R. Mosca et al. "Sanitizing of Confined Spaces Using Gaseous Ozone Produced by 4.0 Machines" winner of the Best Paper Award of The 2021 International Conference of Systems Biology and Bioengineering, World Congress on Engineering 2021, IAENG.

The 4.0 machine performs the sanitization by creating gaseous Ozone, which will be dismantled by the same machine at the end of the treatment, by retracing the phases found in Nature, in the Ozonosphere, described by the Chapman Cycle, thus guaranteeing the deactivation of any microorganism or pathogen such as viruses, bacteria, molds, fungi, spores (and even the elimination of insects) without using harmful chemicals and, also, at low cost (negligible consumption of energy).

Fig. 3. UV-C and Ozone Sanitization machines

Paper [23] describes how an operator can simultaneously handle 2 machines deployed in adjacent rooms, disinfecting an environment of 100m3 with a UVC-Ozone machine equipped with 12 lights of 14W/each in 20 minutes. Positioning, turning on, and shutting off are the main actions taken. As part of routine duties, the cleaning staff is typically given these responsibilities (it takes about 20 minutes at the end of each shift).

A case study is reported again on paper [23] about a building of 4 floors that are each 250 square meters (15 rooms, 5 bathrooms, and an entrance hallway per floor). Two machines, each costing €4,000, for a total expenditure of €32,000 (8 machines: 2 per floor, on 4 floors), will be utilized to sanitize each level. The total cost of treatment for the entire block is €27 for each sanitization performed. It also emerges that every 12,000 hours of operation, the machines require a single maintenance task of replacing the bulbs and other accessories, which will cost €9,600 (total cost for 8 machines). A machine's life cycle is 20 years. In this example study, the average cost of maintenance is 4€ each treatment.

VIII. AN APPLICATION (CASE STUDY)

For these places it was necessary, given their particular characteristics of use by hotel guests, to develop a specific anti-contagion procedure which, for the reasons that will be illustrated below, adopts multiple thermoscanner devices. The solution developed by the team certainly has a positive impact for limiting the spread of the infection by people coming from external areas and who can be unconscious vehicles of the virus. Emblematic, in this regard, the case of that worker of a company (located in Bergamo) who, coming from China, stayed in Italy (in Codogno) and became the first vehicle for the transmission of the virus in Lombardy Region and from there throughout Italy. From this event, the team proposed a procedure that provides for the systematic application of the thermoscanner in the places of possible contagion in order to avoid that, currently with Covid19 and in the future with any other virus or pathogen agent, dramatic situations of this type would occur again. The procedure devised by the team envisages, as a first act, the submission of an informed consent for written acceptance to the Customer of the facility who presents himself for acceptance, signing which he fully accepts the safety procedure attached to the thermoscanners present in the Structure. These devices, in total respect of privacy, operate facial recognition and combine it exclusively with the room number that has been assigned to it. No biometric data will be stored by the facility at the time of check out, nor reported externally except for the positive temperature detection (exclusively to the local Body for Health surveillance).

The guest is also informed that other thermoscanners are placed in the restaurant and in the corridor (Figure 4 and Figure 5) where the room assigned to him is located, in proximity of the lift.

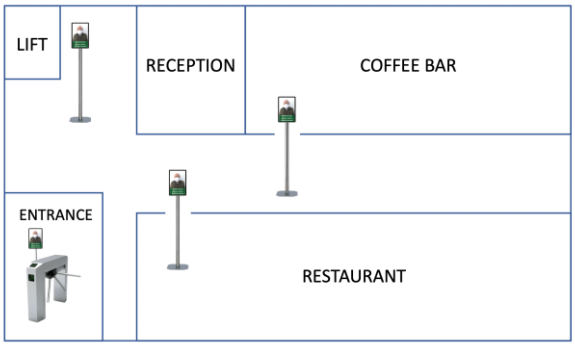

Fig. 4. First step of the Methodology applied to the Ground Floor

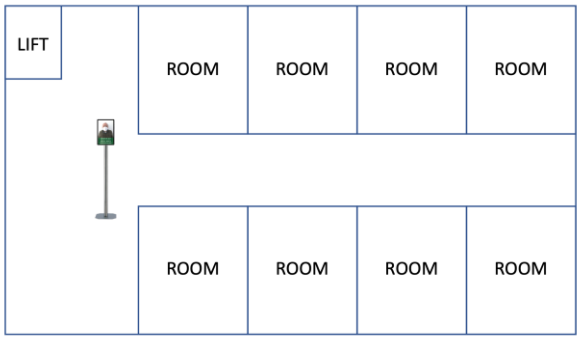

Fig. 5. First step of the Methodology applied to the Upper Floors

The reason for these additional thermoscanners is given by the fact that in the places where people temporarily stay, whether they are hotels, hostels, motels (etc.), they spend a significant number of hours (8-12 in general) in which they could develop the symptoms of the infection, including fever, with all that would follow in terms of the spread of the infection, by subjects who may not have perceived having been affected by the virus. Obviously, in these cases, the positioning of an apparatus at the reception and / or in the restaurant

cannot solve the problem of recognizing a positive in the incubation phase. Analyzing the problem in search of a possible solution to this situation, the team decided to install the thermoscanners in the corridors mentioned above. This installation ensures that those who during the hours of stay in the room have developed feverish symptoms of the infection will be required to go immediately to the room they come from and wait there for the Government Medical Staff notified by the Reception (alerted by automatic system notification) who will arrive appropriately equipped anti-contagion to pick up the unfortunate and, possibly, his guests in the room. Final point is to carry out an extraordinary sanitization with the 4.0 machines (described above) in each area visited by the infected subject. In this regard, it is recommended that the ordinary sanitization procedure is carried out daily in all frequented areas, regardless of the detection of abnormal temperatures, especially in consideration of the fact that these machines do not use chemicals or dirty or pollute the environment.

IX. Conclusions

The proposed Methodology fully achieves the goal for which it was designed, that is:

- First, the thermoscanner provides namely a safe control of the subjects entering certain environments. The term "safe" means both the avoidance of waiting-people gatherings (that normally occur around the detector used for manual temperature control, with frequent bypasses of the same), with the danger that subjects carrying the virus will spread it among those who are waiting , while carrying out the formalities required for access and, also, that of controlling the temperature with extreme precision, including the recognition that gloves and masks are worn, where required, as well as the correct positioning of the mask on the face;
- Second, proceeding subsequently to a professional sanitization of the environments by using proprietary 4.0 machines suitably conceived, conceptualized and developed by the authors to ensure a profound and accessible sanitation to all the Structures.

The project team believes that the processes, procedures and 4.0 devices presented have made an important contribution to contrasting the spread of Covid 19. Thanks to the methodology developed by the authors through the appropriate alerts, those subjects positive for fever will immediately self-isolate and, in a short time, will be taken over by the Health authorities in charge of this task which, in the event of positive pathologies, will provide them with appropriate treatment with the utmost promptness including, if necessary, hospitalization in the intensive care Hospital wards, with the double benefit of slowing down the spread of the virus and to provide for Patient care. It has made a significant contribution to the recognition of symptomatic subjects who can often unwittingly spread the virus and to be able, therefore, to proceed with their isolation in order to avoid that they become a danger to those people who unknowingly come into contact with them. The methodology described was initially designed to counter the spread of Covid 19 by subjects Who, having entered "healthy" hotels, motels or residential structures of any type, develop the infection during the time of their stay. Such methodology can be fully generalized and applied with the same effectiveness to any place where the Persons reside for an adequate number of hours. A typical case is offices and workplaces in general, where They spend up to 12 hours in the same day between breaks of various kinds (coffee machines, canteens, meetings and overtime). Scope of this paper is finally to underline the essential role that the devices conceived, conceptualized and developed by the authors play in the methodology. It should be noted that sanitation is currently used in combination with the thermoscanner to neutralize the effects of symptomatic subjects, but that it should become a daily practice to be sure of avoiding the spread of who knows what other pathogens, a real danger in a globalized world, as already hypothesized by Bill Gates in 2015 at the Ted Talk "The next outbreak? We are not ready ".

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