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Information Technology Innovations in the fight against Covid-19: Evidence of collective responsibility

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Abstract: The COVID-19 pandemic originated in Wuhan China and quickly spread all over the world through human-to-human transmission with global social and economic impacts. The fight against the pandemic encouraged the development of technology-based innovations to mitigate the spread of the virus and ease the social and economic effects. This paper explores the various Information Technology (IT) innovations (published in innovation.com website) in various sectors of the economy to alleviate the impacts the Corona Virus pandemic. In the health sector, virtual reality, Covid precheck app, artificial intelligence (AI) enhanced Covid test app, wireless biosensor patch, web-based telehealth services were the prominent technology innovations. In education, the use of online/virtual platform was key to delivering education in the wake of the pandemic crisis. In food and beverage sector, contactless menu, order, and payment using QR code were the solutions deployed to reduce personal contacts. Under electronics and robotics, social distancing apps, proximity augmented reality, virtual reality remote presence, virtual meeting tool such as zoom, and AI Covid cough detector app were part of the solutions developed in the fight against COVID-19. Moreover, technology-based innovations in other sectors of the economy reveal the impact of collective efforts in promoting personal and group responsibility in the global fight against a health emergency such as COVID-19.

Introduction

The coronavirus disease 2019 (COVID-19) epidemic caused by the severe acute respiratory syndrome coronavirus (SARS-Cov-2) originated in the city of Wuhan in China and spread quickly across the world through human-to-human transmission and has infected people in around 210 countries across six continents [1]. As of 22 December 2022, there are 650,879,143 confirmed cases of COVID-19 and 6,651,415 deaths globally. New cases of COVID-19 are still reported daily around the world with current figure standing at above 281,230, with over 581 new deaths. The USA has the highest number of cases (101,743,845) with (1,112,944) deaths [2]. To curtail the spread of the virus, many countries imposed complete or partial lockdown forcing factories, schools, and businesses to close, except for essential services [3]. COVID-19 is not a peculiar pandemic in the history of mankind, past decades witnessed three deadly pandemics, specifically in 1918, 1957 and 1968 [4]. However, none of the past pandemics witnessed technology driven approaches to fight the crises like COVID-19 has done.

During the COVID-19 pandemic and in global solidarity, innovators were finding new ways to mitigate the impact of the pandemic by offering innovative Information Technology (IT) solutions such as contactless menu [5][6], social distancing [7][8] and contact tracing [9]. Others have used virtual reality to simulate the treatment of COVID-19 [10], while in the fashion industry, augmented virtual reality (AVR) is used to model outfits of major brands in place of in-house models, and projected to online viewer in a 3D virtual world [11]. The goal of these innovations is to reduce the rate of COVID-19 transmission and ultimately save lives.

Overall, the crisis has generated huge economic crisis across the world with significant disruption in production and supply lines, consumption, and investment. Many businesses across sectors are facing various challenges ranging from decline in revenues, job losses and insolvency [12]. High density places like restaurants, museums, cinemas, gyms, stadia have been forced to close, while in other scenarios, organizations have encouraged employees to work from home to mitigate the spread of the virus [13]. As countries are gradually opening their economies, businesses are finding new ways to adapt in the post-covid environment and conform to the new normal [14]. With businesses opening, technology-backed solutions, such as geospatial technology is helping large and medium-sized retailers to decide which outlets to open and which not to. Similarly, manufacturing companies are using geospatial data to analyse their suppliers' catchment areas and effectively plan their sourcing strategies, while logistic companies can use geospatial data for route optimisation of their vehicles [15].

Countries are enacting swift policies at national levels in line with global leadership to limit the spread of the coronavirus [16]. Innovators are complementing national and global efforts by using information technology to drive policy directives aimed at change in social behaviour in addition to promoting individual responsibility during and after the pandemic. A case in point is Google's augmented reality (AR) tool SODAR which helps visualise social distancing rules by displaying a two-meter radius ring around the person, and social distancing app which warns people when another device enters their zone to promote safe social distancing and to help curb the spread of COVID-19 [17]. To help control the spread of the virus, Apple and Google developed a voluntary contact tracing system for iOS and Android that allows users to share health status data via Bluetooth technology [9].

To ensure safety and business continuity in the COVID-19 pandemic, some mobile applications (apps) were developed. Google Singapore launched a food delivery app to make it easier for Singaporeans to support local eateries [6], while Presto, a leading enterprise technology firm developed a 'Contactless Dining Kit', a solution that allows restaurant guests to use their personal mobile devices to order and pay for their food, without the need for touching any foreign surface or contact with people [5]. To prevent COVID-19, telehealth services app was developed by Praava, where people with Covid symptoms can make online consultation with a doctor prior to visiting a health facility to help prevent transmission of the virus [18]. With the imposed lockdown and stay at home order implemented by most governments, many individuals and small businesses are turning to online platforms to showcase their products and services. In this direction, Facebook (Meta) has introduced 'Facebook Shops' to assist small businesses to easily setup online stores [19].

The Corona Virus pandemic has huge mortality figures with unprecedented social and economic impact around the world [20]. Most healthcare personnel and facilities have been over stretched because of the overwhelming cases of infections in many countries [21]. World Health Organization (WHO) is pioneering research and development and bringing health professionals together to develop new norms and standards to contain the spread of the Corona Virus [22]. This step has encouraged and supported creative innovations to help mitigate the impact of the pandemic. Innovators have come up with ideas and innovative solutions to ease the effects of the health crisis and to promote personal and social responsibility. It is important to document and further analyse these innovations from an empirical viewpoint. Hence, this paper focuses on reviewing information technology related innovations in the fight against COVID-19 around the world.

This paper contributes towards advancing knowledge of IT innovations in the fight against COVID-19 globally. The review of IT innovations in the fight against COVID-19 provides a useful toolbox that will promote awareness and possible adoption of the innovative ideas to advance individual, group and corporate responsibilities needed to limit the spread of COVID-19. The innovative solutions can be adopted or adapted at local and national levels as part of policy directives to ensure safety of citizens at all levels.

Methodology

The study design is a descriptive review of Information Technology (IT) innovations published on the website: www.covidinnovations.com. The website has a listing of innovations based on different categories. This paper focused on reviewing innovations in the Information Technology category across various sectors. The sectors include Apparel & Fashion, Architecture, Construction, Consulting, Education, Electronics & Robotics, Energy & Utilities, Financial Services, Food & Beverage, Travel, Government, Health & Fitness, Marketing, Media & Entertainment, Non-Profit, Retail, Home & Garden, and Information Technology. The researcher reviewed and summarized innovations in each of the categories and drew conclusion based on analysis of themes that emerged in each category.

Information Technology Innovations

This section summarizes the information technology innovations in different sectors, viz: Apparel & Fashion, Architecture, Construction, Consulting, Education, Electronics & Robotics, Energy & Utilities, Financial Services, Food & Beverage, Government, Health & Fitness, Marketing, Non-Profit, Retail, Travel & Tourism, Home & Garden, Media & Entertainment, and Information Technology.

Apparel & Fashion: Fashion brands are adopting augmented reality to showcase their brands, [11] [23] [24] allowing customers to view a 3D simulated images of models wearing the brands apparels. The goal is to reduce the amount of clothing samples in store, limit physical contacts between clients and staffs, and helps prevent the transmission of Covid-19 [11] [23] [24].

Architecture: Designers are using artificial intelligence, augmented reality, machine learning and spatial intelligence to imagine home design in post-covid era. The website 'everydayexperiments.com' showcases a series of digital experiments that explore new ways of interacting with spaces around us [25].

Construction: A new app 'smartvid.io' can determine when construction workers do not comply to social distancing. The app figures out the distance between two workers (social distance app) on construction sites using any camera that uses the app to connect to the company's AI interface [26].

Consulting: A consulting outfit ''Upinion'' helps NGOs gain insight from their communities using social media platform such as Facebook and Whatsapp as a communication platform. The tool sends short set of question relevant to the community and the NGOs intervention, and have results published in real-time [27]. *Tech to the Rescue* links IT companies with Non-Governmental Organizations (NGO's) to help the non-profit firms with technology issues such as e-commerce, and software development [27].

Education: Microsoft has made available its educational content through a digital skills platform to assist learning to those affected by Covid. The idea is to combine new and existing resources from Linkedln and GitHub units and make them available for free to those keen at upgrading their skills or retraining for a new career [28]. Huawei ICT academy in Kenya launched an online contactless platform that transitions learners from face-to-face learning to online learning [29]. An immersive online mechanical ventilation training tool, Open Paediatrics' Ventilator Simulator incorporates the most recent evidence-based guidelines in paediatric and adult ventilation. Healthcare professionals can use the online simulator to become acquainted with the use of the ventilator system to treat COVID-19 patients [30].

Electronics & Robotics: In this sector was the emergence of social distancing apps, warning people when a new device enters their domain to promote safe social distancing and to help stop the spread of COVID-19 [7]. Proximity augmented reality technology developed by *Snap Safe* uses AR lens to show a two-metre distance of how far away people need to distance themselves from others in public places to prevent Covid-19 transmission [7]. AVATOUR and Insta360 offer virtual reality remote presence platform that enables people to visit and inspect facilities remotely in real-time using Insta360's 360-degree cameras, providing an alternative to travel during the lockdown [31]. *SPACES* developed an app that allow people to join Zoom meetings from within virtual reality. The app was developed during the COVID-19 pandemic, where many people around the world worked from home and using virtual meeting tools such as Zoom. SPACES allows a user to join a video conference from within VR and use an adjustable virtual camera and whiteboard. The VR user is placed in an environment with a virtual whiteboard and markers, along with an adjustable virtual camera. When the call begins, the other people in the video call join as normal. However, the user in VR will be represented by the virtual webcam showing the avatar in VR. The software was successfully tested with Zoom, Google Hangouts, Facebook Messenger, and Skype [32]. A virtual workspace for companies was developed by VirBELA to helps companies connect their workforces online to host immersive events, meetings, classes, and other gatherings, where workers can meet in a different way [33]. Coughvid app uses AI and your phone or laptop to detect COVID-19 from coughing sounds. The app is a simple web app that can run on any device that has a mic. You cough at it and an AI will determine the type of cough you have and your chances of having been infected with the COVID-19 coronavirus [34]. A programmer Tom Goddard at the University of California, San Francisco created with his colleagues a molecular visualisation program called ChimeraX that enables the molecular visualization and manipulation of 3D models of the COVID virus with a depth-sensing camera and a virtual reality (VR) headset [35].

Energy & Utilities: An app 'DoNotPay' launched by *Chatbot* as a new service help people delay rent, credit card, or utility bill payments. The app requests waivers and payment extensions to both landlords and companies [36].

Financial Services: German merchants can find assistance from leading tech companies using the 'innovation for now' platform that bundles the offerings of major tech companies and make them easily accessible to businesses affected by Covid [37].

Food & Beverage: US-based tech company Presto released free 'Contactless Dining Kit' to assist restaurants post-lockdown. This new tool will assist restaurants that are preparing to reopen dining rooms keep COVID-safe social distancing measures. The kit offers technologies to assist restaurants with contactless order and payment. The contactless menu option lets restaurants place a QR code sticker on tables, which guests can scan to access the menu. Any loyalty or rewards programs the restaurant runs can be integrated into the process. For those guests that cannot use their own device or do not want to, the restaurant can also provide the menu via a Presto tablet placed on the table. The kit's contactless payments feature lets guests pay via their own devices or the Presto tablet on the table [5]. Google in Singapore has launched a menu-sharing app on its Google Pay app to make it easier for consumers to interact with local restaurants and order food deliveries. Singaporeans can use the app to discover menus, choose what they want and contact the restaurant, coffee shop or hawker stall to order and pay [6]**.** US company Paranoid Fan pivots from helping sport fans to supporting food banks. Paranoid Fan was an app helping US citizens going to an NFL game to know where to park or where to find concessions. Due to COVID, the company rebranded and is now called Nepjun, using the same mapping and delivery technology for a new platform that helps food banks and pantries digitise. People can find nearby food banks,

place online orders, and select pickup in a specific time slot or choose delivery [38]. Indian technology provider Devourin offers contactless solution to hotels. Devourin 'Spark In-room' provides contactless experience for both room services and dining at hotel restaurants. A single QR code on your phone opens the doors to a variety of services including digital menu, digital ordering, payment, real-time feedback, or spa appointments [39]. Delhi and Hyderabad airports partner uses intuitive travel app HOI to provide contactless food delivery. The app enables customers to safely order and pick up food before their flight. The app also enables travellers to check their flight status and receive alerts about flight updates. It can also provide boarding gate information and news about the weather conditions at the destination [40].

Government: The government of South Korea asks travellers to the country to download a self-quarantine app to curb the spread of COVID. The GPS-based app helps monitor people self-quarantined at home, by for example setting off an alarm if people leave their designated location [41]. Researchers at the Hong Kong University of Science and Technology (HKUST) developed a solution to assist the government in efficient and cost-effective monitoring of citizens in quarantine during the coronavirus outbreak by introducing geo-fencing technology called 'Signature Home'. The app is a more resource-efficient and friendly way to monitor people under home quarantine. Paired with an electronic Bluetooth wristband worn on the quarantined person, the app can accurately detect whether the home confinee is complying with the quarantine order and alerts the relevant authorities if not [42]. Spanish local councils introduced beach reservations to ensure social distancing to make beaches COVID safe. The idea was to make beachgoers book their space in advance via a mobile phone app, allowing only a certain number of people to enter the beach per day [43]. New telehealth app by LiveMD in the US enables people to self-diagnose themselves using an AI-based integrated tool, report their coronavirus status for tracking, and connect with local government and medical agencies for help and guidance [44].

Health & Fitness: NetObjex based in California launched a COVID PreCheck app to help US workers return safely to work. People who were tested positive for COVID antibodies will be able to get a TSA PreCheck™ style clearance. They will be directed to blood test collection centres in their areas, with results then reported straight to the app. The level of antibodies in a person's system will determine their "pre-clearance" status, with a COVID PreCheck QR code, which can then be shown to employers to help speed their return to work. The app, which uses secure blockchain technology to ensure the privacy and anonymity of data, connects the verified identities of users with their test results. Participants will be directed to blood test collection centres in their areas for an antibody test, and the lab results will then be reported straight to the app. The level of antibodies in a person's system will determine their "pre-clearance" status, which will be sent to the user's mobile device. The PreCheck app enables employers to identify employees at lower COVID-19 risk, who might therefore be able to safely interact with other staff members [45]. Specialist at Annenberg School for Communication created virtual reality video demonstrating treatment for COVID patients. The digital design specialist made this video to prepare medical staff in remote locations to respond to a possible spike in cases. Virtual reality is an immersive technology that benefits medical personnel by generating a 3D, interactive environment in settings that are often hard to simulate with 2D graphics. Through surgery on a mannequin, the video depicts a doctor treating a COVID patient suffering from respiratory failure [10]. London-based health-tech company Babylon launched COVID-19 Care Assistant app. Care Assistant allows users to find continually updated information on COVID, check their symptoms and receive advice and a Care Plan with daily notifications reminders to measure vital signs, information for the 14-day isolation and general tips for their physical and mental wellbeing [46]. Utah-based AI Biokinetic Technologies created AI-enhanced app that could give COVID test results using only your phone. AI Biokinetic Technologies and Aspen Clinical Research are hoping to get a final approval for their COVID AI 19 app which uses AI to give COVID test results, thanks to a thermal temperature reading, an audio analysis, and an X-ray analysis of the lungs, all on your phone [47]. US company LifeSignals works on wireless biosensor patch for early detection of COVID symptoms. The Biosensor Patch 1AX, affixed on the chest area, will record temperature, respiration rate, ECG trace, heart rate and movement, in real-time. The data can then be sent wirelessly from the patch to an app on the user's phone, where it is displayed and analysed [48]. Someplace Safe launched web-based chat to help victims of domestic abuse ask for help. Victims will be able to go to the Someplace Safe website and find a chat now button that will connect them directly to a domestic violence specialist. This will help women who are monitored, stalked, or never left alone calling from home to reach for help by texting [49]. Praava Health, a for-profit organisation in Bangladesh developed telehealth services to cater for people that are experiencing symptoms of COVID-19. In case of non-emergency situations, patients are encouraged to reach out to doctors virtually and have an online consultation before visiting a health clinic to help prevent further infections. The services offered include a virtual awareness 30-minute session with a doctor to learn more about coronavirus and preventive measures, and a 30-minute virtual training session on how to disinfect and clean home and office based on global practices and prevention methods [18]**.**

Marketing: Brazilian initiative #Naodemita committed to social responsibility by encouraging entrepreneurs to commit to not lay off their employees at least for the next two months of the lockdown [50].

Non-Profit: StartupBlink and Health Innovation Exchange launch COVID Innovation Map to provide COVID solutions. This map is a directory of hundreds of innovations and solutions around the world that could support the response to COVID-19, helping people to adapt to life during the COVID pandemic and to connect innovators so they can collaborate on solutions. The map provides information on five categories: prevention, diagnosis, treatment, information and life and business adaptation [51]. Colorado-based *Gloo* provides trusted resources and digital tools for churches and organisations that serve them. In the pandemic, churches moved into a hybrid of physical and digital ministry. *Gloo* provides trusted resources and digital tools for churches, and the organisations that serve them, as they prepare for and respond to the impact COVID is having on their communities [52]. Accenture launched 'Touch', a virtual art project campaign in Denmark. The campaign invites Danes to upload pictures of their hands, along with personal messages of hope. Each image adds a patch of digital "skin" to an AI-generated 3-D hand, serving a mark of the nation's solidarity against COVID. For each hand, Danish retailer Coop will donate 5 kroner (around $1) to Danish Red Cross COVID-19 relief efforts [53]. Instagram and Facebook (Meta) add COVID-dedicated fundraising features on their platforms. To gather funds for COVID-19, Instagram has launched a new fundraising option within Instagram Live, which enables users to raise funds during an Instagram Live stream. Facebook, on the other hand, has added a new feature to its fundraising options to enable business owners to create personal fundraisers to call on their customers for support [54]. Brazilian platform *Precisamos* connects people who need help with those who wish to support them. The platform *Precisamos* enables users to see on a map of Brazil the people who can help or who need help, in real-time, with the possibility to filter by categories like perishable food, talking on the phone, personal care, sewing, technical questions, deliveries or taking out a pet [55]. *Upinion* launches 'COVID-19 Community Monitor' to help NGOs monitor the needs of their communities. The technology helps NGOs gather insights from their communities with a secure communication platform built on top of social media messaging apps like Facebook, Messenger, and WhatsApp. Every week, the tool will send a short set of questions relevant to the community and the NGOs' interventions. Results will be provided through real-time reports [27]. *Tech to the Rescue* helps non-governmental organisations (NGOs) get through the COVID crisis by connecting IT companies with NGOs around the world, to help NGOs with all types of tech-related issues, such as e-commerce, research, fundraising, software development, and more [56].

Retail: Facebook (Meta) introduced Facebook Shops to help small businesses to easily setup online stores for customers to access on both Facebook and Instagram for free. Businesses can choose the products they want to feature from their catalogue and customize the look and feel of their shop with cover images or accent colours that showcase their brand. Due to COVID-19 many small businesses are struggling, and with stores closing, more are looking to bring their business online. Facebook is making shopping seamless and empowering anyone from a small business owner to a global brand to use their apps to connect with customers. This means any seller, no matter their size or budget, can bring their business online and connect with customers wherever and whenever it's convenient for them [19]. Urban Redevelopment Authority of Singapore launched a website to help shoppers avoid crowds in malls by checking how crowded the malls are with colour codes according to current crowd levels, in hopes that people will make better decisions about where to go amid the COVID outbreak. The website provides regular updates to users based on data from retail malls on shopper traffic. Each mall is represented on the map by a coloured circle - green for not crowded, yellow for some crowd, orange for crowded, and red for maximum. Based on the information shoppers can make appropriate decision by changing their plans to go to less crowded malls [57]. *BeRemote* lets you explore local London food deliveries, grocers, child tutoring and more from your home. The website enables Londoners to discover and connect with local businesses in their city remotely, to find grocers, butchers, beer and wine merchants, restaurants, and cafes that deliver to customers' front door. The platform offers entertainment with virtual exercise and yoga classes, child tutoring, cooking lessons, and more [58].

Travel & Tourism: German town Herrenberg recreates itself digitally enabling tourists explore its picturesque city via virtual reality. Tourists can explore the historic churches of Herrenberg via virtual reality, thanks to a digital twin developed with the High-Performance Computing Center Stuttgart (HLRS). The team developed an app inviting Herrenberg residents to share feedback on whether certain locations in the town feel comfortable, unsafe, or ugly, to display these sentiments virtually via emojis [59]**.**

Home & Garden: A free mobile app 'CareMonger' developed by Digital agency in Australia allows people within 10km of each other to request help or offer their services for free. App users are required to set 'I am…' status that lets people in their neighbourhood see what they need, or what they are willing to offer [60].

Media & Entertainment: WeChat Go collaborated with 11 major U.S. museums and all-Mandarin arts and pop culture platform 'Move the Mind' (MTM) to create separate WeChat Mini Programs, non-downloadable applications within WeChat's ecosystem, that further the ability of institutions to engage, inform, and entertain

Chinese audiences. The Mini Programs offer users a range of features such as guided audio tours and video materials, interactive games, and maps [61]. Mexican women protest virtually against femicide in Animal Crossing to denounce violence without leaving home during COVID. It happened just after the Autonomous University of Nayarit (UAN) reported the death of Diana Carolina Raygoza Montes, a 21-year-old who was studying law at the institution, which seemed to be a femicide and raised enormous social indignation [62]. Denmark restarts its football league season with fans taking their usual places via Zoom. AGF Aarhus will welcome local rivals Randers for the reopening of the season, with a giant screen of 40 metres long and 3m high, filled with fans watching via video link. Supporters have signed up for free tickets to take part, with two smaller screens allowing for neutrals and away fans to be there too. The concept was created in partnership with Zoom [63]. Corona Climate Data is a community hub to store, analyse and visualise positive environmental data during the COVID pandemic. With a majority of the world social distancing or in complete lockdown, our way of life has slowed and changed. The website shows how this has positively affected climate-change related indicators [64]. Facebook (Meta) releases messaging app *Tuned*, allowing couples to stay more connected. The new Facebook app allows couples to create a digital scrapbook to help them cope better with social distancing and lockdowns. "With Tuned, you can be as mushy, quirky, and silly as you are together in person, even when you're apart," the app's description reads. The mobile app can be used to exchange messages, music, photos, and other content to build a digital scrapbook. You can also set your mood, connect Spotify accounts, send notes, cards, and voice memos, and use standard Facebook stickers and reactions [65]. Snapchat launched a new set of filters designed to encourage its users to donate money to help fight COVID. The AR filters allows users to scan 23 international currency notes across 33 countries. The app will then give people the option of donating directly to the UN COVID-19 Solidarity Response Fund which supports the World Health Organization [66]**.**

Information Technology: Transerve Technologies in India launched a Geospatial Technology to map COVID-19 density zones. The system works on predictive analysis and uses layers of geospatial data to track, monitor, analyse and visually represent them into data stacks. These data stacks will help in route optimisation in COVID positive zones that will help businesses in making statistically driven decisions. Large and medium-sized retailers who are now eagerly waiting to re-open their stores are heavily dependent on geospatial datasets on deciding which outlets to open and which ones not to open. Similarly, big-ticket manufacturing companies are using the geospatial data to analyse their suppliers' catchment areas and effectively plan their sourcing strategies. Supply chain professionals across organisations and logistic companies can use geospatial data for the route optimisation of their vehicles [15]. Brazilian Foundation Luis Eduardo Magalhaes launches website with real-time information about COVID cases in Brazil. The website uses the State Health Departments and other sources to provide real-time information. This information includes ranking regions with active cases of coronavirus and showing a map of Brazil with the most infected areas and cities [67]. *Maptician,* a startup based in Georgia, US launched Maptician Flex. The Flex software analyses floor plans and seating charts for risks around employee desks and in conference rooms, break rooms, and walkways. It also suggests options for staggering employee schedules based on where each worker sits and capacity restrictions and has a built-in contact tracing system to help identify staffers who might be in danger should a colleague get sick. The software is in the list of others emerging to boost workplace functionality in a post-coronavirus world. These programs reorganize office seating charts, create custom staffing calendars, and track employee health over time [68]. UK recruitment company Beamery launches #NewHome to help people affected by layoffs during COVID find their next role. This service is for people whose job has been affected by COVID-19. Beamery's technology is connecting those talents with recruiters at companies that are still hiring [69]**.**

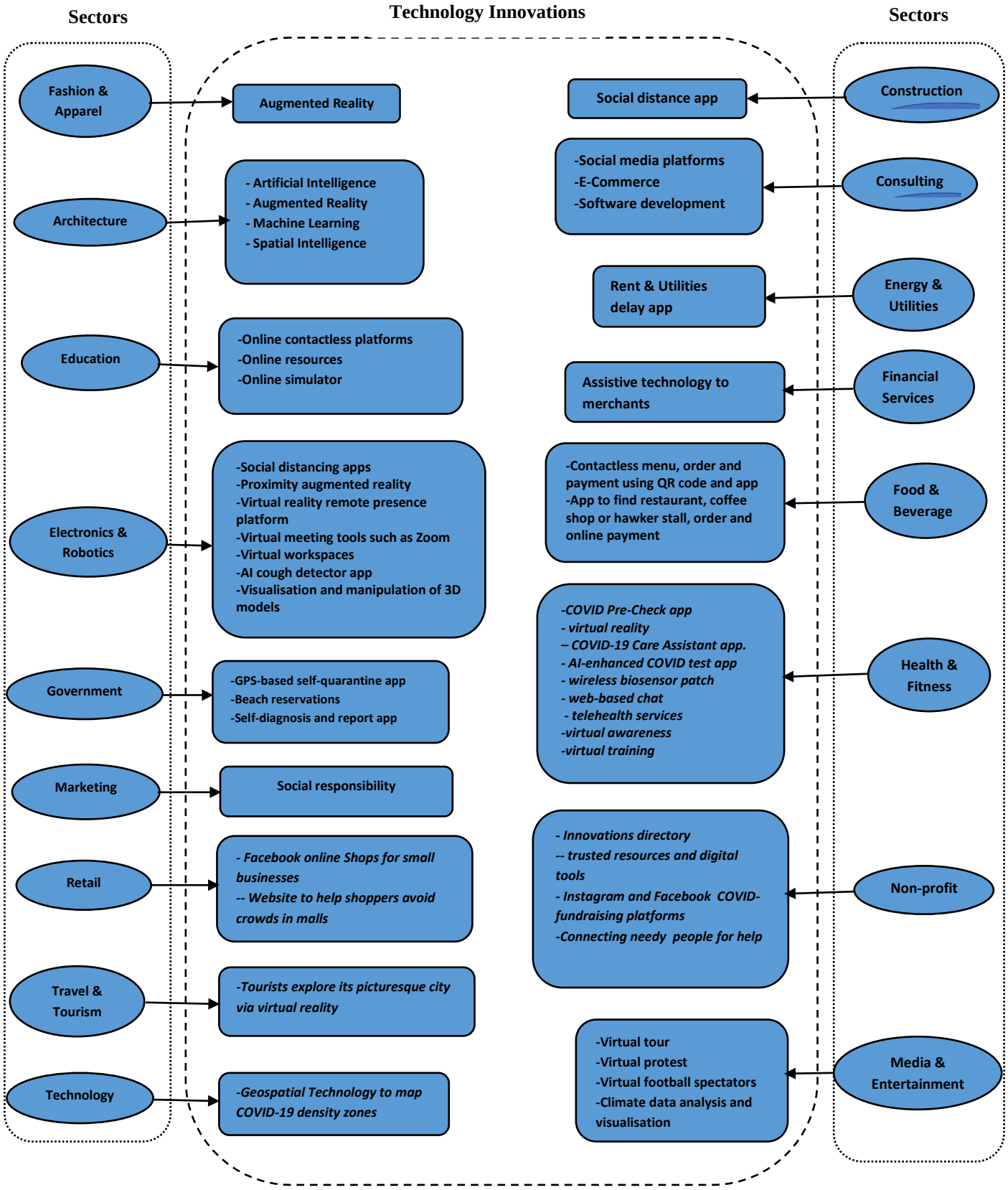

Figure 1: Summary diagram of IT Innovations in the fight against Covid-19 across sectors

Discussion

The coronavirus pandemic has a significant impact on the global economy and on our social lives. Businesses are responding to the changing social and cultural norms of the post lockdown by investing in and adopting innovative technology-backed solutions to ensure business continuity and resilience in the 'new norm'. Augmented reality, artificial intelligence, machine learning, spatial intelligence, contactless solutions, social distancing apps are all part of the technologies used by businesses to create innovative solutions to navigate the crisis. Continuity in the education sector amid the pandemic means educational contents must be delivered to learners in online mode to replace the face-to-face contacts to curb the spread of the virus. Many institutions around the world have adopted the contactless online platform for educational delivery to save the academic year while keeping learners safe. Restaurants and hotels are adopting varied contactless solutions to limit staff-customer exposure to the virus, using QR code to access digital menu, make orders and payment. In similar instance, app is used as contactless measures by travellers to safely order and pick up food, check flight status and receive flight updates. In tourism, virtual reality has proved very successful in bridging the real world and its virtual counterpart. Tourist can explore faraway historical artefacts in a more convenient virtual space and avoid visiting crowded museums and exhibition centres. Virtual reality is altering the norms of video conferencing as virtual avatars can be manipulated and used to make presentation to real live video conferencing audience. As an immersive technology, virtual reality has benefitted the medical profession as it can generate a 3-dimensional environment that can be used to demonstrate Covid-19 treatment to less experienced doctors in remote locations. In the world of fashion, augmented reality is used by brands as an alternative to real live fashion shoots. With this technology, customers can see a simulated view of models wearing items from the brand, thereby keeping both customers and staff safe. Keeping safe distance and prevent the spread of Covid-19 is the idea behind using proximity augmented reality technology by Snap Safe to help people keep a safe two-metre physical distance. Geospatial Technology with its affiliated global positioning systems, geographical information system and remote sensing collects data used to map coronavirus density zones and helps organizations to make data-driven decisions. The innovative solutions show the power of collective responsibility of individuals, businesses, and organizations in confronting one of the worse health pandemics in human history.

Conclusion

This article reviewed information technology innovations to alleviate the coronavirus pandemic in education, food and beverage, health and fitness, travel, media and entertainment, apparel and fashion, electronics and robotics, government, non-profit and retail sectors in different parts of the world. Fashion brands used augmented reality simulated images of models in the place of in-shoot person models to showcase their brands, helping to curb the spread of the virus. In education and training, online contactless platform is pioneered as an alternative to face-to-face learning mode, while immersive and non-immersive virtual reality is mainly used in the health sector for training on treatment of Covid19. In the electronic and robotics category, social distancing apps, proximity augmented reality, virtual reality, remote presence platform, virtual workspaces, artificial intelligence, are all parts of the technologies used for various innovative solutions in the fight against Covid-19. The food and beverage sector necessitates gathering, a potent ground for COVID-19 transmission. The application of Information technology in the form of digital menu and payment in this sector have promoted safety and prevention from COVID-19. In government settings information technology applications and geo fencing technology are innovative solutions adopted by some governments for contact tracing and monitoring those in quarantine to curb the spread of the virus. In health and fitness category, virtual reality was used to demonstrate treatment of COVID-19 for medical staff in remote location, while an AI technology company developed an app that uses AI to give Covid test result using temperature reading and other parameters. Innovative solution in early detection of COVID-19 was pioneered by a US company with the development of a biosensor patch to detect Covid-19 symptoms. Providing access to resources and digital solutions to churches and organization was the focus of a Colorado based NGO, while raising funds for COVID-19 was the motivation for Facebook and Instagram to include a COVID dedicated fundraising features on their platforms. In retail, Facebook introduced Facebook shops to assist small businesses setup online stores for free. In travel category, virtual reality was used by a German town to recreate the city picturesque digitally for easy exploration by tourist. In media and entertainment, U.S. museums and Chinese arts and pop culture platform provided a guided tour audio and video tour of US museum for Chinese audience. In Mexico, women protested virtually against femicide without leaving their homes due to Covid, while in Denmark, football league season started with fan taking position via zoom. The innovative solutions offer adaptive ways for business continuity and individual lifestyles without compromising health safety. Developing technology innovations by various firms is a hallmark of collective responsibility and ethical response for the common good of all global citizens.

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Competing Interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

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