
rrrreflect. Journal of Integrated Design Research
Volume 1 (2023)

Epidemic Geographies

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Kulturwissenschaften

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Date of Publication: November 14th, 2023

DOI : <https://doi.org/10.57684/COS-1225>

URN: urn:nbn:de:hbz:832-cos4-12251

<https://rrrreflect.org>

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This paper is based on the final thesis by the author which has been supervised by Prof. Dr. Carolin Höfler and Prof. Dr. Lasse Scherffig

Epidemic Geographies

As the Covid-19 pandemic began to unfold in spring 2020, governments across the world realized that drastic approaches were needed to contain the spread of a virus whose scale was unparalleled in decades. While many states introduced lockdowns that aimed to minimize infections by shutting down public life, another approach was to trace contacts between infected and non-infected persons, enabling a targeted instead of general quarantine. What then became known as *contact tracing* initially began by asking infected individuals for places they had visited and people they have met, but later on was automated by using the citizens' own smartphones to collect this data. In most states, this smartphone-based contact tracing was achieved using peer-to-peer Bluetooth technology. For this, whenever two people using the respective app came in close contact, their phones would exchange pseudonymized identifiers and (for most states) record them locally on the users' mobile devices.^[1] In case of infection, the app would then notify all recorded connections so that their users were able to isolate themselves to avoid further spreading of the virus. However, a different approach was chosen by the South Korean authorities who not only saved those connections in a centralized database but also used the devices' GPS information to record infected individuals' geographical positions. This data was then used to map infection cases in national epidemic cartographies, accessible through public websites such as www.coronamap.site. This approach proved to be particularly successful as it helped South Korea to relax its lockdown months earlier than most other countries.^[2]

There are two things at stake in this essay: First, I ask why the South Korean approach to contact tracing has been so successful in its utilization of cartographies to mitigate the epidemic. While my study maintains a focus on urban spaces where the virus spreads the quickest and thus rapid approaches for epidemic mitigation are needed the most, I argue that part of the answer is that the South Korean authorities early on have understood the epidemic as a new and distinct element in the multilayered web of infrastructures that organize urban life and spaces.^[3] In section A

of this essay I followingly retrace why the epidemic has to be understood as infrastructure itself by outlining how it develops similar principles of spatial organization as other urban actors. Specifically, this is done in comparison to the transportation service Uber's dynamic pricing model *Surge*. Surge pricing provides its users with maps that, according to demand in specific areas, cluster the city into zones of varying prices. I outline how Uber's maps are restructuring the economical, jurisdictional, and political models of urban life as they divide the city into various zones defined by the company's algorithmic determination. Following this, the hypothesis of this section is that the South Korean cartographies have been so successful in epidemic mitigation because they operate in a very similar way. Instead of being merely depictions of the country's epidemic geographies – a kind of infographic –, they were used as operative tools for urban navigation: both on the scale of the individual moving through the city while avoiding high-infection locations, but also on the scale of legislative urban planning seeking ways to reduce clusters in the first place.

In section B, I first outline how the South Korean approach varies from Bluetooth-based contact tracing applied by most other states not only in its spatial but also in its temporal operation. While the former provides a tool to be actively used by uninfected individuals, the latter only passively records (possible) infections and thus does not work as such a preventive tool. I then go on to ask if also for the Bluetooth-based approach, a similar tool could be developed that enables active prevention while maintaining a focus on decentralization. To answer this question, I am comparing both approaches of contact tracing to an old dispute of two different conceptions of space, which started with the two contemporaries Gottfried Wilhelm Leibniz and Isaac Newton: The first advocated for a relativist understanding of space (which I set analog to Bluetooth-based contact tracing), the latter argued for an absolutist notion of space (which I set analog to the South Korean location-based approach). Both, however, developed their spatial conceptions based on the *position* of things. Against this backdrop, I argue that while the Bluetooth-based contact tracing apps are lacking any positional determination, the

South Korean maps' success lies not in their choice of geographic representation but in their focus on the position of infected individuals. In reference to Leibniz' concept of space, section B thus asks: What would a non-geographical map look like that enables Bluetooth-based contact tracing for preventive mitigation of the epidemic? How can it be made productive, but at the same time, what problems of social stigmatization would it entail?

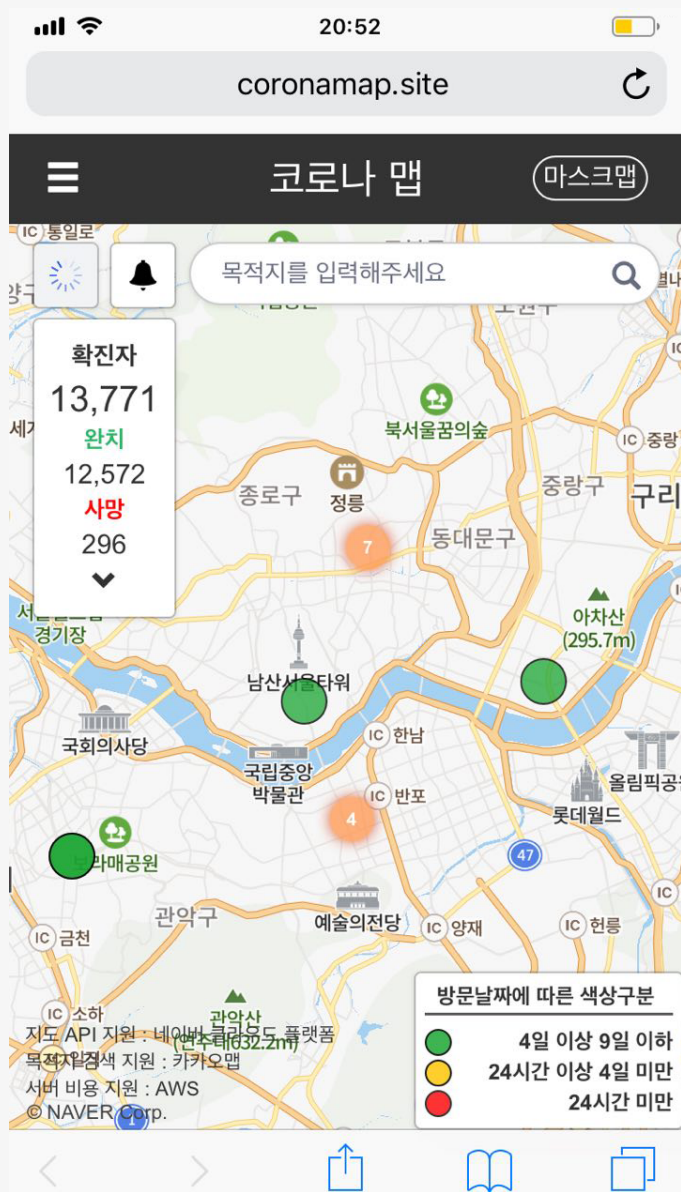


FIG 1 The South Korean website www.coronamap.site maps infected persons' positions as a cartographic overlay. © www.coronamap.site

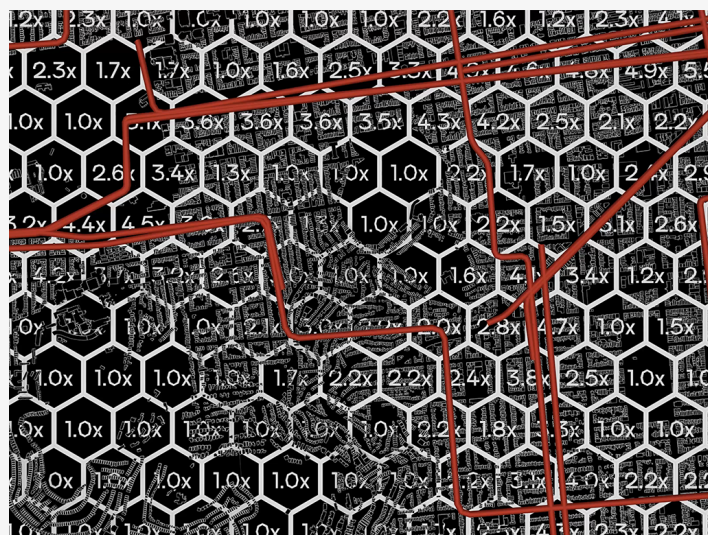


FIG 2 Still from the video work 1 accompanying the essay. Uber's Surge pricing in San Francisco. Red lines visualize exemplary Uber rides, Hexagons the H3 coordinate system, numbers the pricing factor. © Finn Steffens

A – Absolute Geographies

Visiting www.coronamap.site, a popular website used daily by many South Koreans during the epidemic, one sees a map of the country overlaid with many green, orange, and red dots, indicating cases of Covid-19 infection. Zooming in, these dots are marking locations accurate to the individual house. Zooming out, they gather to form clusters of different sizes and intensities.^[4] What we see here is what I call the *epidemic layer* which I understand as the totality of infected persons' positions in the city that collectively create a kind of network that superimposes the urban geography. As www.coronamap.site visualizes, the epidemic layer can be imagined as a distinct overlay which renders new markers on top of the existing cartographic layout, seemingly independent from the various layers below (see fig. 01).

To understand why exactly the epidemic layer is in fact not independent from the city's infrastructures, processes, and affordances – in other words, urban space itself –, some theoretical derivations are necessary to establish a suitable framework to discuss the epidemic layer's geographical effects. For www.coronamap.site, mapping locations with high and low densities of infection cases produces what I call *directional spaces*. In their most prominent form, directional spaces take the form of zones that are clustered according to defined parameters, as, in this case,

the rate of infection cases. Those zones visible in the South Korean cartographies are (re-)mapping factors of inclusion and exclusion as well as attraction and repulsion in the urban geography that alter the way people are navigating the city. The following section will discuss this epidemic division of the city in reference to the concept of the *new urban zone* which will help outlining how the epidemic develops similar principles of spatial organization as other urban actors.

The New Urban Zone

Dividing the urban landscape into various kinds of zones has been a common practice in city planning for a long time. As it separates different kinds of permitted and prohibited land uses (e.g., residential or industrial), it lays out distinct districts as adjacent areas that organize the city's layout. However, over recent years, a more informal zoning of the urban topography has emerged through the establishment of privatized services as geographical actors: Uber strives to absorb all personal transportation services, Airbnb restructures the housing market, and Deliveroo and Foodora relocate the entire gastronomical sector.^[5] Each of these platforms on their own, but also all of them together, engender a rearrangement of the urban condition to which a jurisdictional response can often only be formulated retrospectively. For example, as Airbnb blurs the boundaries between lodging and residential use, legal decisions have to be made whether offered accommodations should be allowed in residential zones or not. And while these much-needed legal frameworks are still being debated, the gentrifying effects of the service are already creating new layers on top of the traditional topographical zones or restructuring them altogether.^[5:1]

This new kind of urban zone may be temporary or permanent, planned or emergent. In any case, it forms new vertical layers as multiple zones may

very well be placed at the same geographical location. They are mapped over the urban topography, stacked on top of each other and then fold back into one another: Their individual modes of spatial organization often do not operate independently but intertwine and produce new arrangements in their interactions. The urban zone is a directional space per se, yet its regimes of inclusion and exclusion may vary from social, economic, legal, or political implications.

In current urban research, mainly legal and commercial clusters of the platform economy are considered as forming these new kinds of zones.^[5:2] However, in the following, I will argue that the epidemic geographies represented in the South Korean cartographies produce zones with very similar characteristics of organizing spatial conditions to economic or political urban zones. In this sense, the South Korean approach of geositional contact tracing can be compared to a dynamic pricing model of the public transportation company Uber. The company's pricing model *Surge* creates dynamic zones in the drivers' and users' mobile maps, offering higher earnings, respectively charging higher prices, in areas with greater demand. Uber frames this method as "rebalancing the marketplace".^[6] Based on the number of users' inquiries and drivers logged on to the system, the price calculating algorithm is "specific to different areas in a city, so some neighborhoods may have surge pricing at the same time as other neighborhoods do not".^[7] For this purpose, the company developed its very own geographical coordinate system *H3*. Based on a hexagonal shape, it divides the planet into equal areas while maintaining a flexible resolution. From the scale of the globe down to the "hyper-local marketplace"^[8], *H3* allows Uber to assign dynamic prices to individual hexagons or accurately compile multiple hexagons to larger zones. While in the finest resolution, the hexagon's edge length can be less than a meter, Uber usually deploys a base resolution of one city block.^[9]

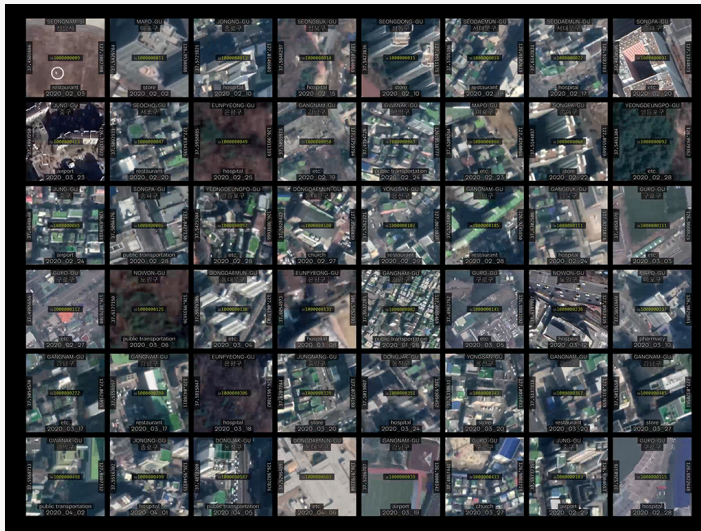


FIG 3 Still from video 1. The pandemic layer over Seoul. Visualization of data by the South Korean Centers for Disease Control and Prevention. Yellow lines indicate patients' routes, numbers pseudonymized identifiers. © Finn Steffens

Here, the zone is manifested in the overlay of many individual movements; it is rendered as an accumulative geography as it dynamically responds to the spatial distribution of user demand (see fig. 03). This market-based configuration of the city has immediate implications on the actions of drivers and users, but it has the potential to change the urban geography long-term, mapping areas with higher demand as city zones of greater importance.^[10] While not bound to historical urban districts or the formalized zones of city planning, mapping these zones' boundaries produces new urban relations that divide the geographic space very much in the same way as the former official categorizations do. For Uber, information about the patterns is not only of great value for their algorithms but has grown to be a standalone by-product with the launch of the *Uber Movements* brand. Addressing "cities as a customer", Uber advertises this product as offering new insights into mobility and transportation for city planning.^[11] Yet their marketing slogans fail to mention that this is Uber's own type of mobility that strictly follows the algorithmic determination.

The Epidemic Layer

For South Korea's Covid-19 cartographies, the inscription of the positions of infected persons manifests itself similarly to Uber's zones by accumulations of supply and demand. In the

conjoined visualization of the individual points, a pattern in the city becomes apparent that, just like Uber, does not merely exist as an independent layer but actively influences other urban spatial processes (see fig. 04). For the case of the position determination by the South Korean cartographies, this can directly guide orientation and navigation on a small scale, as some routes may appear safer than others. On a larger scale, however, this can also lead to areas with a particularly high number of infected persons being avoided and areas with a lower infection rate being visited more frequently. Thus, for citizens with a particularly high risk of infection, these maps draw zones that they may not be able to enter at all.

Reconsidering the initial remarks, these processes produce directional spaces that map new factors of inclusion and exclusion onto the urban geography. But in contrast to the originally static concept of the zone, these spaces are constituted dynamically, possibly even in real time. These new zones are no longer bound to the administrative order but only emerge in the accumulative superimposition of many individual actors. However, this is not to say that the constitution of new urban topographies is free from geographical restructuring of the scope of jurisdiction. Covid-19 very explicitly showed how the emergence of epidemic zones leads to a fragmentation of the legal situation which tries to react to the different conditions in the individual zones.^[12]

Still, clusters of high infection rates correlate with other aspects of the city geography, e.g., densely populated districts or contact-intense work environments. The epidemic layer is as much carried by the urban infrastructure as it is part of it itself: In Keller Easterling's words, the epidemic acts like "spatial software"^[13] that organizes many of its surrounding processes.^[14] Only in this case, its dispositions shaping urban space are anything but subliminal. With constant news coverage and, specifically in South Korea, daily informational text messages from the government, these dispositions of urban organization and restriction are apparent as never before. Just as Easterling describes infrastructure space, the epidemic layer yields "an interplay of active forms" whose "object of design is not a single form but an apparatus for shaping many forms".^[13:1]

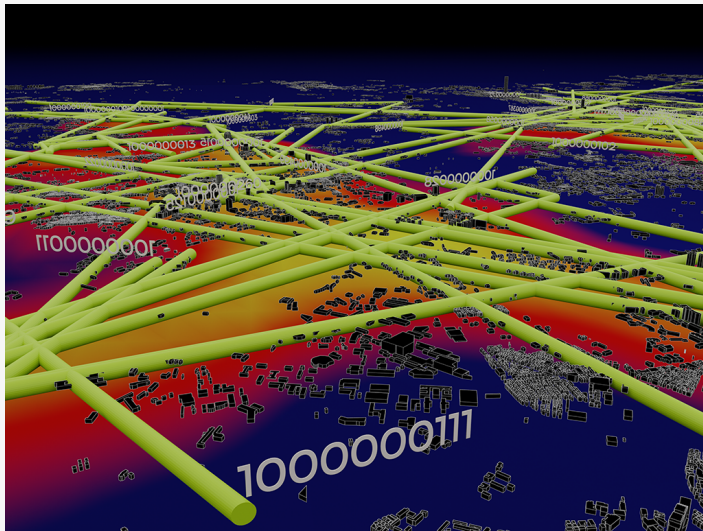


FIG 4 Still from video 1. Brighter areas indicate a higher density of infection cases. © Finn Steffens

Heatmap Urbanism

As already stated, the data of both the patients' positions in the South Korean contact tracing and the routes of Uber's drivers are represented as overlays on the standard urban cartographic layout. In its aggregated state, this data is often visualized as heatmaps, differentiating areas with dense amounts of data points from areas with relatively few points (see fig. 05). Yet these heatmaps are not simply statistical representations, not just infographics of urban infrastructures and social interactions. These maps themselves are part of the constituent circle, the feedback loop, of urban space: They affect the behavior of the individual in the lesser scale and of city planning in the larger scale. The directional spaces, thus, are only constituted by the simultaneous spatial visualization of data when drawing the map. As remarked by the developer of the South Korean www.coronamap.site, this data would remain ineffective in its tabular representation.^[15] In this sense, these accumulative cartographies produce the very urban space they claim to represent.

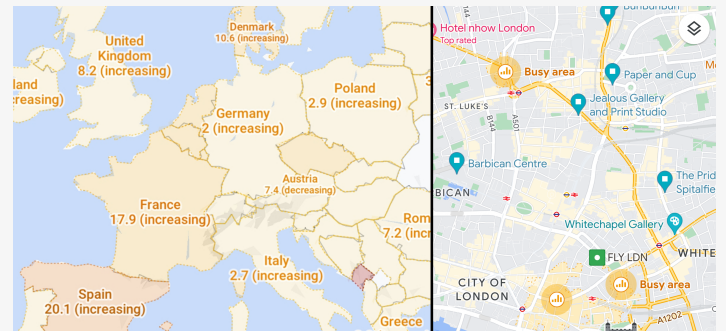


FIG 5 During the pandemic, also Google Maps has adopted a cartographic interface for pandemic navigation, literally as a 'covid layer'. On a larger scale, this shows regional numbers of infection as heatmaps. On a smaller scale, the service now indicates 'busy areas', allowing to make conscious choices for urban orientation. In early 2023, with a declining pandemic both features are no longer available. © Google

Thus, I argue that the traditional model of cartography delimiting adjacent zones is insufficient for understanding the geographical dynamics of the processes discussed above. This is due to the fact that the new urban zones are no longer produced by the nomos of the dividing line: These dynamical and directional spaces are not constituted through directive order but emerge as the result of many individual processes, to which a jurisdictional response can often only be formulated retrospectively. These processes – here, epidemic contact tracing as well as Uber's demand and supply pricing – are no longer bound to any adjacency, but only become effective as they intersect and overlay one another. Each layer on its own is a system of many points and lines connecting the points. And while urban space can be regarded as the arrangement of many layers stacked on top of each other, the previous remarks made it clear that the vertical is again strictly bound to the horizontal: Only through the horizontal relatedness – and thus through the dispositions of the individual layers – do the vertical organization become effective. As these layers constitute spatial relations in their interactions, they fold back into each other, producing urban space in their intersections and superimpositions, their amplifications and contradictions.

B – Relative Topographies

So far, section A of this essay has discussed the epidemic in its capacity to reorganize urban spaces and how map-based contact tracing is successful precisely because it acknowledges and

utilizes this. For this approach, one keyword is crucially important: position. For South Korea, the position of infected persons is the focus for the government's measures. By knowing the position of infected persons, the contours of virus hotspots can be deduced which thus enables to draw connections between the epidemic and the city's structural dispositions. However, the previous section of this essay strictly remained within a geographical concept of space. In geographical space, position is a numerical attribute of things, people, or places, usually determined within the two-dimensional array of latitude and longitude. In the following section, I will theoretically outline how position as a concept can also be deployed for contact tracing without the reference to geographical space to then use this discussion to develop a speculative cartography for Bluetooth-based contact tracing.

Retroactive versus Preventive Epidemic Mitigation

In its basic application, contact tracing focuses on people who are unknowingly infected as it aims to isolate them to reduce further transmissions. While the South Korean maps are doing exactly this, they also provide means to those not infected, allowing them to avoid contact with the virus in the first place. I call this a *preventive* approach, as it shifts the focus from those infected to those not infected. Indeed, the main reason why governments deployed Bluetooth-based instead of location-based contact tracing are different conventions of data privacy as the former does neither reveal the person's identity nor relies on the centralized collection of data, as it is only two phones that are exchanging pseudonymized identifiers. But this renunciation of location also meant the renunciation of cartographical, and thus preventive, ways of containing the epidemic.

The next section addresses the lack of epidemic maps in Bluetooth-based contact tracing and speculates on possible approaches to non-geographical epidemic cartographies. For this, I will discuss how the concept of position can still provide a viable reference if its focus on the geographical is replaced with the relational. If successful, the developed cartographic concept not only poses questions, issues, and opportunities

of symbolic representation of the epidemic, but also contributes to what is missing in Bluetooth-based contact tracing: active prevention for uninfected persons.

Non-geographical Spaces

In a *Science* article from 2013, Dirk Brockmann, current head of the project group *Epidemiologically Modeling of Infectious Diseases* of the German Robert Koch Institute, and fellow researcher Dirk Helbing argue for “replacing conventional geographic distance by a measure of effective distance”^[16] to achieve more accurate epidemiological models. They refer to the proximity of two places not by their geographical locations but by their connectedness via strong links, e.g., long-distance transportation networks. This link may be more of a factor in spreading the virus than individual traffic to another nearby city. [16:1]



FIG 6 People lining up for a supermarket in Chulucanas, Peru.
© https://www.instagram.com/p/B_EjkcPJE8v/

Deploying effective distance approaches means replacing the geographical with a non-geographical space for more accurate

epidemiological modeling. The concept indicates that knowledge about the characteristics of geographical space is often just not necessary to facilitate epidemic orientation and navigation. Hence, one of the most prominent recent global imperatives has been to maintain two-meters distance relative to each other (see fig. 06). As the world reorganized around this new norm, an old debate around different notions of space resurfaced that has a long history, both in the fields of physics and sociology. In *The Sociology of Space*, Martina Löw illustrates the controversy over absolute and relative concepts of space by the dispute between the contemporaries Isaac Newton and Gottfried Wilhelm Leibniz. While the former presupposed a rigid concept of space that saw it as a container for things to be placed in, the latter on the contrary saw space as resulting only from the relations between those things.^[17] It then may seem counterintuitive that Leibniz describes space as the “quintessence of possible positions in general”.^[17:1] However, he provides a decisive reinterpretation of the concept of position that is influential for the notion of position to be developed here: Instead of defining the position of a point in empty space as Newton did, Leibniz describes its position by relating it to the positions of other points. While these themselves still represent scattered individual entities, for him space introduces the ordering principle that organizes their relations. From this thought Leibniz derives a principle which will prove of central importance for the discussion of Bluetooth-based contact tracing: With the correlation between position and relation, it also results that space is no longer a static construct independent of an observer but is constituted differently from different perspectives.^[16:2]

For Leibniz, this leads to the rejection of any spatial conception in coordinate systems. Yet conversely, in the context of this essay, the value of coordinate systems should be maintained, but only under the premise that their “direction” has to be inverted: Here, the individual does not move in space, but space extends outward from the individual. As a consequence, the frame of reference used for absolute space is no longer suitable for relative space. In its most popular articulation, the absolute frame of reference is in line with the planetary coordinate system of

latitude and longitude. Even if this is indeed linked to the Earth’s rotation, in general physics it can often be simplistically assumed to be at rest: It is a so-called inertial frame of reference.^[18] For this general geographical coordinate system, an observer can be imagined who has a bird’s eye view of the reference frame.

In the case of the geographical contact tracing, a symbolic observer can be identified quite easily: It is the South Korean government recording infected persons’ positions. However, for the case of the relative Bluetooth-based contact tracing, this outside observer no longer exists, simply because the geographical data is not available. Instead, many scattered individual frames of reference emerge, one for each smartphone running the Bluetooth-based contact tracing app. While in the geographical view these individual entities were considered to be in constant motion, now each smartphone becomes its own point of reference. It observes its environment from its own point of view and thus takes a static position: It sees the other devices moving relative to its own position, not the opposite.

Cartographic Speculations

Departing from these considerations of relative position, the next sections outline some speculations of how a cartographic model could also be applied to Bluetooth-based contact tracing without any references to geographical frameworks. First and foremost, this cartography explicitly does not aim to produce a global map of the epidemic space but instead takes an ephemeral and situated form that is strongly bound to its usage. As much as this approach draws from the existing Bluetooth-based contact tracing apps, it extrapolates from their current functionality to enable the switch from being passively used by (potentially or unknowingly) infected persons to actively being used by those not infected yet, thus supporting the epidemic prevention as outlined above.

At the same time, this cartography also inherits the limitations of current contact tracing. For this reason, it is to be regarded as a speculative medium: While it may enable a sense of epidemic orientation and navigation, it may very well also pose new issues of social stigmatization and data

privacy. In alignment with the method of speculative design, I position it ambiguously between both extremes, oscillating between being productive and provocative as it stimulates discussions in both domains. Thus, to actually draw those maps is not only to be done for conceiving productive measures for confining the spread of the virus, it is also a means to put this very approach up for debate, to question and to criticize it.

So how can relational topographies be mapped? What kind of reference system does this cartography rely upon? What scale does it operate in? What are the control parameters of its visualization? What is its symbology, i.e., what kind of compass and legend does it use? What are the issues; what are the opportunities of such cartographic concepts that renounce static representations and instead rely on a situated approach that adapts to the user? How can those contribute to a general reconfiguration of urban spatial models that withdraw from top-down representation and favor emergent relatedness?

Point of Reference

This cartography does not aim to represent the traditional geographical topographies usually displayed by maps. It does not locate individual entities (neither persons nor places) in a horizontal grid and also does not make any absolute claims about them. Any observation, any measurement, any claim, and any deduction always start from the point of view of the individual using the contact tracing application. The elements being mapped are constantly moving; their status is constantly updating and possibly changing. Thus, to turn to the individual as the point of reference is not a flaw of this cartography; it is a necessary precondition to make any claims at all.

The existing Bluetooth-based contact tracing apps work similarly to radar technology yet fall short of its functionality as they do not give any real-time information. As those apps only record but do not display detected objects, they operate like a radar without the radar screen. This is the void I want to address with this cartographic concept. The existing apps transmit short-length radio waves and receive incoming waves which are used for the

detection of objects. For a radar system, those objects reflect the transmitted signals which allow the receiver to classify them according to their angle and distance. Currently, relational contact tracing apps use Bluetooth protocols that measure the proximity between two devices by mapping the signal strength to a distance range. The better the connection, the closer the apps assume their respective users to be. This indeed shows limitations in the case that, e.g., those individuals are separated by a glass wall, but in their basic principle these apps deploy a unidimensional coordinate system.

In turn, what this system does not measure is the users' relative positions, the direction the signal is coming from and thus their relative angle. As much as the cartography developed here adheres to the existing Bluetooth-based contact tracing, in this point it actually deviates from the current apps' technical functionality. To determine the relative position to another device, I propose to use a different radio protocol called ultra-wideband (UWB), which has become a common technology installed in smartphones. UWB is able to provide real-time location data between two devices without the need for the triangulation needed for Bluetooth location finding.^[19] This functionality thus allows us to further develop the image of the radar screen into an actual coordinate system.



FIG 7 Still from video 2. The epidemic space in its network visualization. The preventive cartographies works as the flashlight that illuminates the individuals immediate surroundings. © Finn Steffens

As this coordinate system renounces the consistent and universalizing rectangular grid of

geographical position, it instead arranges around the central point of reference, the individual user. Like radar organized around the center of the screen, this coordinate system is pinpointed to the center of the individual using the smartphone. It extends from this point outward as far as the specific UWB sensor is capable of detecting, potentially up to 100 meters.^[19:1] Following the visual concept of the radar screen, the mutual relative positions are then not only provided by the localization of the other individual within one's own relative coordinate system, but it is also the entanglement, the superimposition of both coordinate systems that marks points of contact. Transferring this into the graphical language of the cartographic concept developed here allows us to clearly map points of contact visually as the overlapping and intertwining of those individual coordinate systems. The larger the area of this overlay, the greater the probability of infection (see fig. 07).

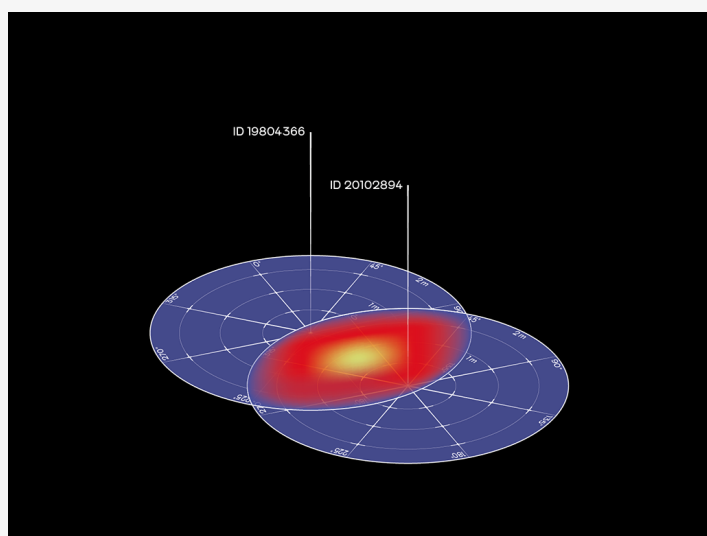


FIG 8 The entanglement of coordinate systems marks the risk of infection: The larger the area of the overlay, the greater the probability of infection. © Finn Steffens

So, how can we imagine using such a map? As it is attempted to map the epidemic geographies produced by Bluetooth-based contact tracing, it stands to reason to speculatively implement the

map into precisely these same apps. And since this mapping approach focuses on the immediate live environment of the user, one technology is particularly attractive in this context: augmented reality. The smartphone's camera could overlay the cartographic interface on the surroundings and trace the relative positions of other users (see fig. 08). This dynamic and mobile approach to cartography underlines its contingency on the users themselves and indicates their relational presence. Using augmented reality emphasizes the map's aim to provide orientation and navigation in the epidemic city. At the same time, the entanglement of the cartographic interface and the user's surroundings reinforces its speculative character by making its social implications ever more explicit. Here, the epidemic division already apparent in the South Korean cartographies gets mapped onto the actual environment, reducing the abstraction of the map to the real-world context. To directly see people's infection status increases the map's ambiguity between productivity and dubiousness and supports its binary nature. Thus, my intention to develop this speculative cartography is not so much to draw a perfect solution, but also to participate in the discussion of social stigmatization that is inherent to any means of epidemic mitigation. As other authors have argued before^[20], we cannot understand the epidemic by focusing on merely the scale of the individual nor society at large, but always need to think either as necessarily conditioned by the other. As much as the virus spreads from one individual to another independent of nationality, (mostly) personal characteristics, or geographical location, it is carried by all the various layers of infrastructure that lead to these two people meeting at this specific place and time. To understand epidemic space then is to uphold both absolute and relativist concepts of space at the same time—and its navigation relies on constantly weighing individual rights against society's well-being.

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