In order to develop feasible implementations for a mobile phone application to combat the spread of Covid-19, there are several topics that need to be researched for information necessary to incorporate in the app. Here, several of these topics will be listed together with information gathered from the relevant scientific papers.

Privacy

There are three different types of privacy (Post, Robert C., 2001) in terms of knowledge, dignity and freedom. The first of which is a form of protection of people's personal information, not allowing it to be public knowledge where it has no context and can be used unrestrictedly.
A second view on the definition of privacy is not having dignity in aspects of social life being violated, since people experience common values as necessary for their own identity. Lastly privacy can be described as something protecting personal views and values from those of society, by keeping certain subjects off limits for the public to scrutinize.

These definitions lead to the question which definition is relevant for the "corona app" and what boundaries should be set to protect in its employment. There appear to be two types of privacy involved in measuring boundaries, namely objective and subjective privacy (Calo, M. Ryan, 2011). Objective privacy harm is defined as personal information used to justify adverse action against that person, e.g. in case of the corona app being quarantining someone based on whether they are infected with Covid-19. Subjective privacy harm would be emotional or internal harm to a person due to being observed or due to the perception of being observed, e.g. in the case of the corona app this could be emotional distress caused by the fact that an individual knows it is somehow being monitored by the app. It is important to note that no actual monitoring has to take place for subjective privacy harm to occur, nor does a sentient being need to see acquired sensitive information in order for objective privacy harm to occur. This arms one with a well-rounded definition of privacy to accurately pinpoint which types of privacy harm can be accepted for the benefit of societal well-being and which types of privacy harm cannot be tolerated under any circumstance.

GIS technologies

A range of practical online and mobile GIS and mapping dashboards or applications for tracking the Covid-19 epidemic and associated events are described in (Kamel Boulos, M. N., & Geraghty, E. M., 2020) . Some of these dashboards and applications are receiving data updates in near-real-time (at the time of writing), and one of them is meant for individual users (in China) to check if the app user has had any close contact with a person confirmed or suspected to have been infected with SARS-CoV-2 in the recent past. This is particularly useful to our project due to it having the same nature and intended purpose as the application described in the paper. Also additional ways GIS can support combatting infectious diseases are described, such as predictive risk mapping using population travel data, tracing and mapping contacts across space and time and analysis of social media response to disease spread, but all are too convoluted to be summarized concisely here.

Virus spread modelling

(Zhan, C., Tse, C., Fu, Y., Lai, Z., & Zhang, H., 2020) deals with the modelling of the spread of the Covid-19 virus and estimating a total number of infected individuals. For this a number of computation techniques are used, among which is model fitting with linear algebra, as well as data from many different cities across the Hubei province and China as a whole. Despite their estimations not being accurate at all in hindsight, the methods for obtaining the estimations does not need to be questioned because of this. This is due to the fact that much of the parameters of the calculations depend on data that, at that point in time (January and February of 2020) could not possibly be very accurate or reliable. Due to the longevity of the pandemic, current data comes from a much larger sample size, making it much more reliable and thus producing more reliable outcomes.

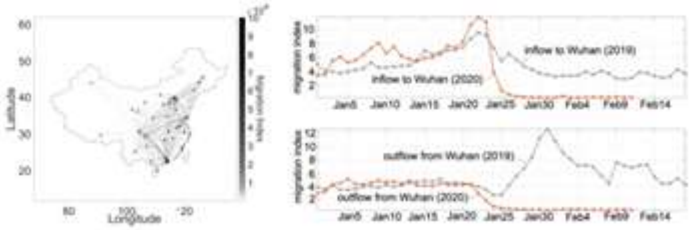

Figure 3: Intercity travel network with arrows showing direction and darkness of lines indicating migration strength (left); total inflow/outflow of travellers to/from Wuhan from/to other Chinese cities using Baidu Migration data (right). Inflow and outflow data of each city with individual cities are also collected to form m_{ij}.

provide the migration strengths of cities which are indicative measures of the human traffic volume moving in and out of individual cities and administrative regions, as depicted by the inflow and outflow networks shown in Figure 3. Based on the collected data, we construct the *migration matrix*, which is given as

$$M(t) = \begin{bmatrix} m_{11}(t) & m_{12}(t) & \cdots & m_{1K}(t) \\ m_{21}(t) & m_{22}(t) & \cdots & m_{2K}(t) \\ \vdots & \vdots & \ddots & \vdots \\ m_{N1}(t) & m_{N2}(t) & \cdots & m_{KK}(t) \end{bmatrix}. \quad (1)$$

The usage of linear algebra and data mining in the pursuit finding a model to predict the spread of Covid-19 in terms of direction and magnitude

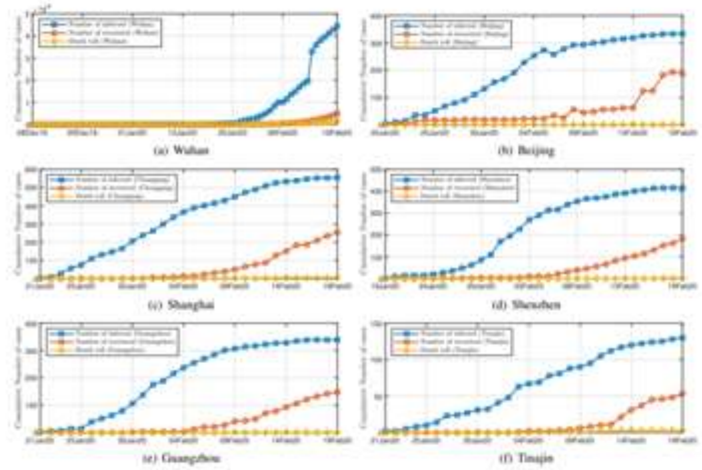

Figure 2: Daily data of COVID-19 infections in six Chinese cities from December 8, 2019 to February 13, 2020. (a) Wuhan (available from December 8, 2019); (b) Beijing (available from January 20, 2020); (c) Chongqing (available from January 20, 2020); (d) Shenzhen (available from January 19, 2020); (e) Guangzhou (available from January 21, 2020); (d) Tianjin (available from January 21, 2020).

Types of input data (estimated number of infections, cured and deceased at a point in time) utilized as parameters in calculations in order to produce the desired prediction model

Teledermatology applications

(Kochmann, M., & Locatis, C., 2016) describes research into the current state of dermatology at a distance through the usage of mobile phone applications (such as the corona app). The main purpose of the research was to make a comparison between the apps in terms of user-friendliness, diagnostic quality and the quality of service of these applications. Conclusions drawn from these comparisons regard the SoTA of the branch in general and include remarks on necessary improvements in the fields of viable interfaces, services and related costs and risks regarding privacy and data storage, all of which are useful to take into consideration in the development of the corona application.

Table 1. Comparison Between Apps and "In-Patient" Examination

	APP A (MOST POPULAR)	APP B (MOST POPULAR)	APP C	APP D	APP E	IN-PERSON
Interface user friendliness						
CC/triage method	Free text	Pick list	Free Text	Free Text	Free Text	
No. of disease categories	All	All	All	All	All	
No. of HPI questions	1	21	8	7	1	
No. of of PMHx questions	No	14	13	2	1	
Chronic illness	No	Yes	Yes	No	No	
PSHx	No	No	Yes	No	No	
Hx of immunosuppression	No	Yes	No	Yes	No	
Psych Hx	No	No	No	No	No	
Hx of blistering sunburns	No	Yes	Yes	Yes	No	
Medications (Rx, OTC, Vit, Herbal)	No	Yes (all)	Yes, No (vit,herbal)	No	No	
Allergy	No	Yes	Yes	No	Yes	
Social Hx	No	Yes	Yes	Yes	No	
Fam Hx	No	No	No	No	No	
No. of ROS system question asked	No	1	No	No	No	
Ability to free text	Yes, only	Yes	Yes	Yes	Yes	
No. of photos to be submitted	2	Unlimited	2-8	Unlimited	Unlimited	
Image guidance or quality control	No	No	No	No	No	
Diagnostic accuracy						
Diagnosis	Enlarged and/or infected sebaceous cyst or gland	Folliculitis	Folliculitis	Folliculitis	No response	Folliculitis
In-person agreement	No	Yes	Yes	Yes	–	
Treatment and recommendations	See in person dermatologist for antibiotic Rx	Rx: Clindamycin topical 1% gel, OTC: Benzoyl peroxide 10%	Rx: Doxycycline PO, Clindamycin topical 1%, OTC: Benzoyl peroxide 10%	Rx: Cleocin T gel, Triamcinolone 0.1% lotion	No response	OTC: Benzoyl peroxide 10%
In-person agreement	No	Yes	Yes	Yes	–	
Service						
Geographic availability	All states	18 States	27 States	1	1	
Price	$24.99	$40	$79, advertised as $59	$65	$ free	$35 copay
Response time	<48 hrs	<24 hrs	<48 hrs	<24 hrs	No response after 7 days	
Follow-up	No	Yes, 2 weeks	No	No	Unknown	Follow-up as needed
Note	• Only offers diagnosis and OTC trt, no eRx	• Patient could not triage himself into disease categories because of medical terminology • Offers Case manager	• Allergies and medications could not be recorded accurately • Sent report to PMD	• MD inquired about med and allergy after consult • After payment notified that app is not available in rest state	• App belongs to charity foundation	

CC, chief complaint; eRx, electronic prescription; HPI, history of present illness; Hx, history; OTC, over the counter; PMD, primary medical doctor; PMHx, past medical history; PO, by mouth; PSHx, past surgical history; ROS, review of the system; Rx, prescription; trt, treatment; Vit, vitamins.

Impression of the type of comparison made between the 5 applications and on what aspects focus laid

References

Post, Robert C., "Three Concepts of Privacy" (2001). Faculty Scholarship Series. Paper 185.
Link: https://digitalcommons.law.yale.edu/cgi/viewcontent.cgi?article=1184&context=fss_papers

Calo, M. Ryan (2011) "The Boundaries of Privacy Harm," Indiana Law Journal: Vol. 86: Iss. 3, Article 8
Link: https://www.repository.law.indiana.edu/cgi/viewcontent.cgi?article=1016&context=ilj

Kamel Boulos, M. N., & Geraghty, E. M. (2020). Geographical tracking and mapping of coronavirus disease COVID-19/severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic and associated events around the world: How 21st century GIS technologies are supporting the global fight against outbreaks and epidemics. *In* *ternational Journal of Health Geographics*, *19*(1), 8, s12942-020-00202–00208. https://doi.org/10.1186/s12942-020-00202-8

Zhan, C., Tse, C., Fu, Y., Lai, Z., & Zhang, H. (2020). Modelling and Prediction of the 2019 Coronavirus Disease Spreading in China Incorporating Human Migration Data. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3546051

Kochmann, M., & Locatis, C. (2016). Direct to Consumer Mobile Teledermatology Apps: An Exploratory Study. *Telemedicine and E-Health*, *22*(8), 689–693. https://doi.org/10.1089/tmj.2015.0189