Epidemics Prevention and Control Based On GeoHash

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Figure 1. GeoHash technology for geographic grid division

Abstract

COVID-19 (Coronavirus Disease 2019) which is a contagious disease caused by SARS-CoV-2[2] was first detected in Dec. 2019. Until today 2021, this virus is still spreading around the world. Before the vaccine is widely vaccinated or the release of specific medication, Many measures have been taken by people to prevent the spread of the epidemic. For instance: hand hygiene, social distancing and quarantine. In a special period, we have to quarantine the high-risk groups and lock down seriously infected regions. Here we propose a kind of dynamic grid division technology based on **GeoHash** used to monitor, screen and control the epidemic areas. **GeoHash** is a public domain geocode system invented in 2008 by Gustavo Niemeyer[7]. We divide a map into several grids and use **GeoHash** to encode the information of each grid. Through the computer visualization technology, **GeoHash** can be easily restored to original digital map. The map is mainly used for epidemic prevention and control, so is named **"Epidemic Map"**. Each grid on such **epidemic map** includes the information of regional security and other important characteristics which are concerned by medical work. Dynamic grids on the map can be scaled for monitoring area of different scopes. The vital information and the results of quantitative analysis of the data on each grid are of great help to epidemic prevention in our application experiments. Such a kind of geographic information system can be used not only for preventing and controlling COVID-19 pandemic, but also be applicative in instances of other epidemic diseases.

Keywords: GeoHash, COVID-19, big data, ASI, epidemic prevention and control, visual analysis, infectious disease

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1 Introduction

During the COVID-19 pandemic, many cities over the world were forced to lock down. Wuhan City and the major cities in Hubei, China were put under lockdown on the 23rd and 24th of January, respectively[6]. Lockdown meant the whole region was quarantined and cut off physical contact with the outside world. The citizens were forbidden to leave their city or even their houses. The national medical team carried

out centralized medical observation and treatment in quarantined cities. And such quarantine makes positive effects on preventing the spread of coronavirus. Research shows, COVID-19 spread became weaker following lockdown[6]. However the lockdown of a city can cause huge economic losses. The lockdown of Some vital areas can cause irreparable losses, such as financial center, political center, and industrial dependent cities. The current lockdown and prevention method is based on the administrative division as figure 2. Cities, states or provinces all over the world have different sizes and irregular geographic borders. There may be an outbreak in a city, but it does not mean that it spreads to all corners of the city. On the contrary, there may be no epidemic in the center of neighboring cities, but there may already be a huge risk at the border with these surrounding cities. Figure 2 is a map that shows the initial locked down cities in Wuhan province, a white block surrounded by red blocks is not secure, even if it is not locked down.

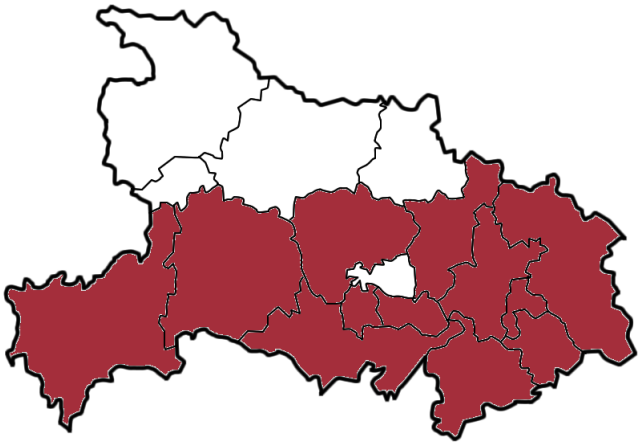


Figure 2. Map of locked down administrative divisions of Hubei. [Public domain], via Wikipedia. (https://en.wikipedia.org/wiki/COVID-19_lockdown_in_Hubei).

We summarize the main weaknesses as follows:

1. The border of a city is irregular and the transmission of virus doesn't follow the administrative division, so the prevention and lockdown can be not accurate.
2. The administrative size of a city is fixed, but the disease is spreadable, so the region of lockdown can not be expanded flexibly.
3. The information obtained by the residents is asymmetric with that released by the government.

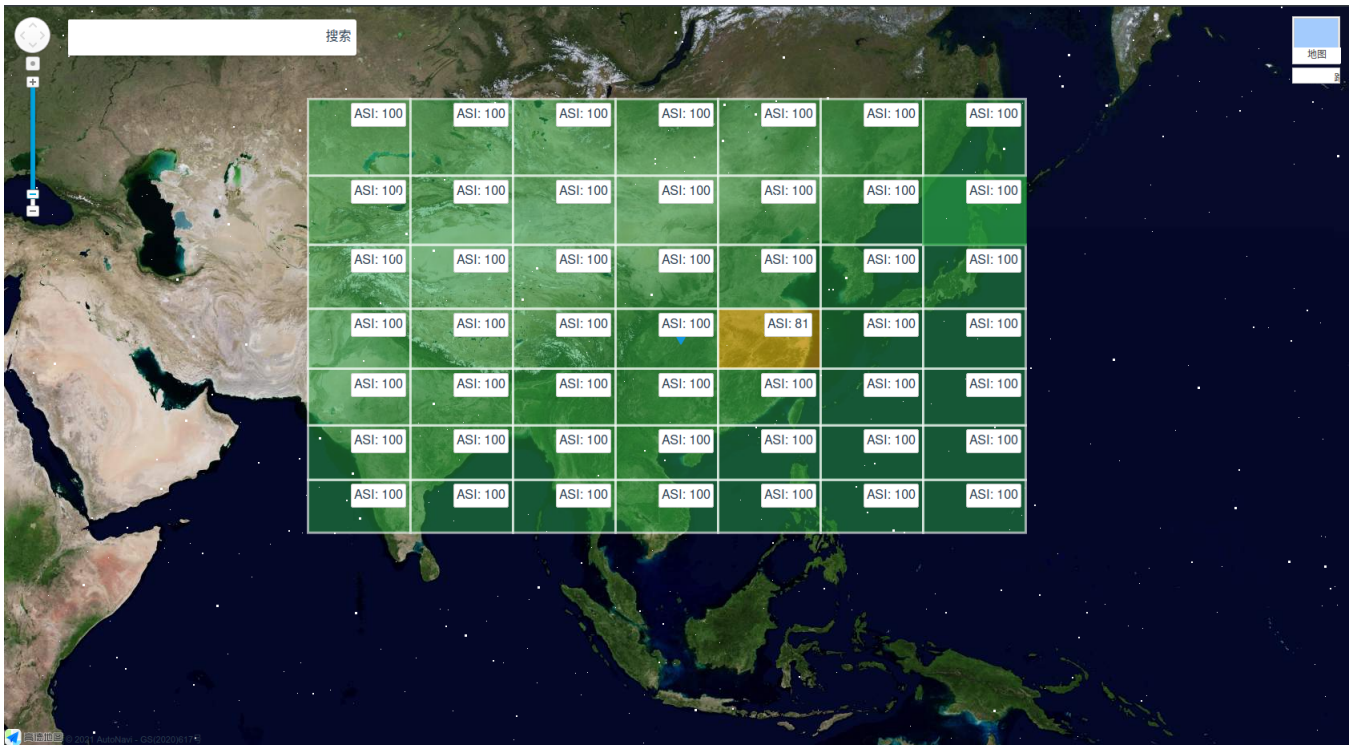
Based on above points of view, it is not the best way to observe and control the epidemic area through the administrative division. For infectious diseases, we have abandoned the common administrative methods. And we have adopted a technology based on GIS (Geographic Information System)[1]. **GeoHash** is used to divide the map into several geometric blocks. The 2-dimensional geometric blocks on the map are encoded by GeoHash, they are reduced to 1-dimension and stored as string in any databases. These blocks are presented as regular geometry, but can be scaled according to the needs of different observation scope.
Meanwhile, we do this technology is because it has the following advantages when controlling epidemic situation:

1. The blocks divided by geohash is regular geometry, and the shape can be customized by observer.
2. The blocks are generated dynamically and they are scalable according to the scope of infection.
3. By combining with GIS, information about the epidemic situation can be encoded in geohash or directly saved.
4. Block data can be quantified, especially safety index.
5. When such a GIS is released to the Internet, users get epidemic information in real time.

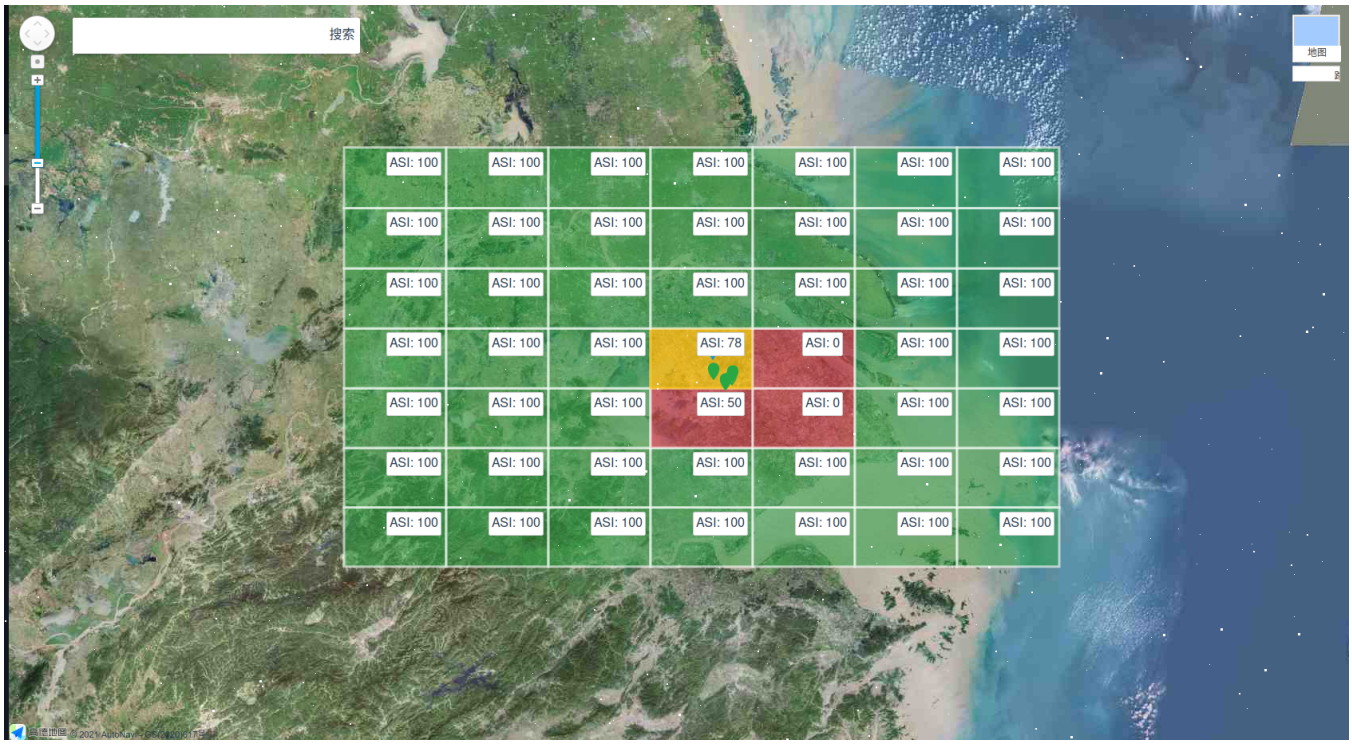
In the practical and experimental scenarios, we use mobile application and web technology to develop such a particular GIS for medical prevention and treatment as Figure 3. It works for medical workers as a visual auxiliary tool and share the results of epidemic data analysis. The **ASI** in Figure 3 is a value of "Area Safety Index". **ASI** represents the risk level of a region. The system contributes to enlighten and support decisions of governments, medical institutions, users, and other researchers who are doing the similar research with us.
The core idea of this technology is dividing dynamic blocks. A block has the following characteristics:

1. Blocks are regular geometry connected with each other. It can be understood as cellular grids.
2. Blocks can be scaled on the map.
3. Blocks are created only when they are meaningful.
4. Scaling is limited, with the smallest and largest block size.
5. Blocks scaling levels are discrete sizes, not continuous.
6. A block stores structured data, which can be used for computing and analysing various attributes.

The last item in the above list means that the purpose of dividing by blocks is to quantify the characteristics. These quantified eigenvalues are the key indicators and references for epidemic prevention and control.
We will also introduce some other related work in preventing epidemic by using similar modern information and visualization technology. Then we focus on how we use **GeoHash** to divide dynamic blocks, and explain the process of quantifing various block values from perspective of algorithm combined with engineering. Finally we will give our experimental and test data, and summarize the conclusion.



(a) larger scale



(b) smaller scale

Figure 3. Dynamic blocks with ASI in GIS

2 Related Work

There are some mature cases of controlling and treating COVID-19 pandemic by using information technology and Internet data. Many studies on COVID-19 have recently emerged, and various data science applications combating the pandemic have been reported recently[5]. The main effects of these systems or applications are listed as follows:[4]

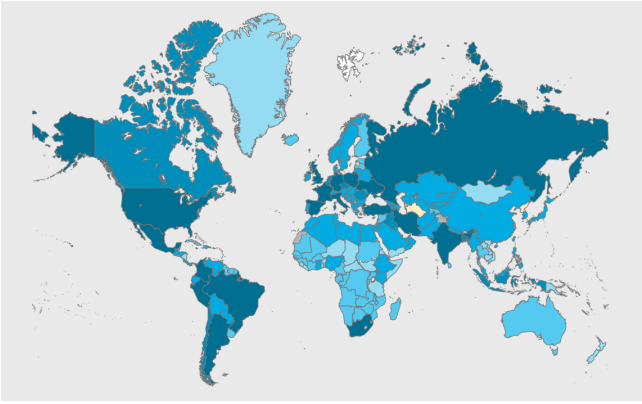
- Tracking of people's movements.
- Early warning of high-risk areas.
- Screening of asymptomatic potential infections.
- Drug development.
- Information release and policy support.

2.1 Data Visualization

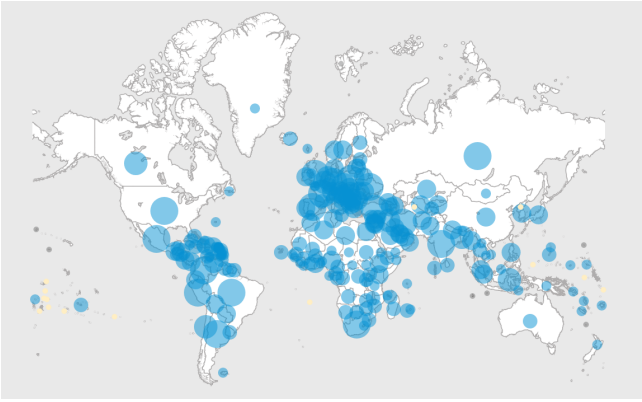
This is one of the most basic ways to implement visualization of epidemic data through computer visualization technology. It presents data to users by drawing charts and graphics, in which the data is represented by symbols, such as bar charts, line charts, pie charts, maps and etc[3].

Figure 4 shows the global COVID-19 epidemic situation in the form of map charts. Epidemic maps are updated by WHO (World Health Orgnaization)[1] in real time, to display the number of cases around the world. Maps in Figure 4 uses two styles of presentation: choropleth and bubble. One uses the shade of color to show the severity of the epidemic situation in each country, and another uses the bubble size to show the number of infections. No matter what kind of map, its role is to help the local people understand the severity of the epidemic, and help the government to take actions to treat the epidemic situation. These two figures (Figure 4) are similar to the previous Figure 2, except that Figure 2 shows the data of one province, so it only supports the province and its subordinate cities. These contents in these maps include: confirmed cases, deaths, historical cases, added cases, and lockdown status.

The disadvantages of such maps are discussed in section 1: **Introduction**.



(a) Choropleth Map



(b) Bubble Map

Figure 4. WHO coronavirus disease dashboard. [Public domain], via WHO. (https://covid19.who.int/).

2.2 Template Parameters

3 Modifications

Modifying the template — including but not limited to: adjusting margins, typeface sizes, line spacing, paragraph and list definitions, and the use of the `\vspace` command to manually adjust the vertical spacing between elements of your work — is not allowed.

Your document will be returned to you for revision if modifications are discovered.

4 Typefaces

The "`acmart`" document class requires the use of the "Libertine" typeface family. Your TEX installation should include this set of packages. Please do not substitute other typefaces. The "`lmodern`" and "`ltimes`" packages should not be used, as they will override the built-in typeface families.

5 Title Information

The title of your work should use capital letters appropriately - https://capitalizemytitle.com/ has useful rules for capitalization. Use the `title` command to define the title of your work. If your work has a subtitle, define it with the `subtitle` command. Do not insert line breaks in your title.

If your title is lengthy, you must define a short version to be used in the page headers, to prevent overlapping text. The `title` command has a "short title" parameter:

```
\title[short title]{full title}
```

6 Authors and Affiliations

Each author must be defined separately for accurate metadata identification. Multiple authors may share one affiliation. Authors' names should not be abbreviated; use full first

[1] https://www.who.int

names wherever possible. Include authors' e-mail addresses whenever possible.

Grouping authors' names or e-mail addresses, or providing an "e-mail alias," as shown below, is not acceptable:

```
\author{Brooke Aster, David Mehldau}
\email{dave,judy,steve@university.edu}
\email{firstname.lastname@phillips.org}
```

The `authornote` and `authornotemark` commands allow a note to apply to multiple authors — for example, if the first two authors of an article contributed equally to the work.

If your author list is lengthy, you must define a shortened version of the list of authors to be used in the page headers, to prevent overlapping text. The following command should be placed just after the last `\author{}` definition:

```
\renewcommand{\shortauthors}{McCartney, et al.}
```

Omitting this command will force the use of a concatenated list of all of the authors' names, which may result in overlapping text in the page headers.

The article template's documentation, available at https://www.acm.org/publications/proceedings-template, has a complete explanation of these commands and tips for their effective use.

Note that authors' addresses are mandatory for journal articles.

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The ACM Reference Format text is required for all articles over one page in length, and is optional for one-page articles (abstracts).

8 CCS Concepts and User-Defined Keywords

Two elements of the "acmart" document class provide powerful taxonomic tools for you to help readers find your work in an online search.

The ACM Computing Classification System — https://www.acm.org/publications/class-2012 — is a set of classifiers and concepts that describe the computing discipline. Authors can select entries from this classification system, via https://dl.acm.org/ccs/ccs.cfm, and generate the commands to be included in the LaTeX source.

User-defined keywords are a comma-separated list of words and phrases of the authors' choosing, providing a more flexible way of describing the research being presented.

CCS concepts and user-defined keywords are required for for all articles over two pages in length, and are optional for one- and two-page articles (or abstracts).

9 Sectioning Commands

Your work should use standard LaTeX sectioning commands: `section`, `subsection`, `subsubsection`, and `paragraph`. They should be numbered; do not remove the numbering from the commands.

Simulating a sectioning command by setting the first word or words of a paragraph in boldface or italicized text is **not allowed.**

10 Tables

The "`acmart`" document class includes the "`booktabs`" package — https://ctan.org/pkg/booktabs — for preparing high-quality tables.

Table captions are placed *above* the table.

Because tables cannot be split across pages, the best placement for them is typically the top of the page nearest their initial cite. To ensure this proper "floating" placement of tables, use the environment **table** to enclose the table's contents and the table caption. The contents of the table itself must go in the **tabular** environment, to be aligned properly in rows and columns, with the desired horizontal and vertical rules. Again, detailed instructions on **tabular** material are found in the *LaTeX User's Guide.*

Immediately following this sentence is the point at which Table 1 is included in the input file; compare the placement of the table here with the table in the printed output of this document.

To set a wider table, which takes up the whole width of the page's live area, use the environment **table*** to enclose the table's contents and the table caption. As with a single-column table, this wide table will "float" to a location deemed more desirable. Immediately following this sentence is the point at which Table 2 is included in the input file; again, it is instructive to compare the placement of the table here with the table in the printed output of this document.

Table 1. Frequency of Special Characters

Non-English or Math	Frequency	Comments
Ø	1 in 1,000	For Swedish names
π	1 in 5	Common in math
\$	4 in 5	Used in business
Ψ_1^2	1 in 40,000	Unexplained usage

Always use midrule to separate table header rows from data rows, and use it only for this purpose. This enables assistive technologies to recognise table headers and support their users in navigating tables more easily.

11 Math Equations

You may want to display math equations in three distinct styles: inline, numbered or non-numbered display. Each of the three are discussed in the next sections.

11.1 Inline (In-text) Equations

A formula that appears in the running text is called an inline or in-text formula. It is produced by the **math** environment, which can be invoked with the usual `\begin . . . \end` construction or with the short form `$ . . . $`. You can use any of the symbols and structures, from α to ω, available in LaTeX [**?**]; this section will simply show a few examples of in-text equations in context. Notice how this equation: $\lim_{n\to\infty} x = 0$, set here in in-line math style, looks slightly different when set in display style. (See next section).

11.2 Display Equations

A numbered display equation—one set off by vertical space from the text and centered horizontally—is produced by the **equation** environment. An unnumbered display equation is produced by the **displaymath** environment.

Again, in either environment, you can use any of the symbols and structures available in LaTeX; this section will just give a couple of examples of display equations in context. First, consider the equation, shown as an inline equation above:

$$\lim_{n\to\infty} x = 0 \tag{1}$$

Notice how it is formatted somewhat differently in the **displaymath** environment. Now, we'll enter an unnumbered equation:

$$\sum_{i=0}^{\infty} x + 1$$

and follow it with another numbered equation:

$$\sum_{i=0}^{\infty} x_i = \int_0^{\pi+2} f \tag{2}$$

just to demonstrate LaTeX's able handling of numbering.

12 Figures

The "`figure`" environment should be used for figures. One or more images can be placed within a figure. If your figure contains third-party material, you must clearly identify it as such, as shown in the example below.

Figure 5. 1907 Franklin Model D roadster. Photograph by Harris & Ewing, Inc. [Public domain], via Wikimedia Commons. (https://goo.gl/VLCRBB).

Your figures should contain a caption which describes the figure to the reader.

Figure captions are placed *below* the figure.

Every figure should also have a figure description unless it is purely decorative. These descriptions convey what's in the image to someone who cannot see it. They are also used by search engine crawlers for indexing images, and when images cannot be loaded.

A figure description must be unformatted plain text less than 2000 characters long (including spaces). **Figure descriptions should not repeat the figure caption – their purpose is to capture important information that is not already provided in the caption or the main text of the paper.** For figures that convey important and complex new information, a short text description may not be adequate. More complex alternative descriptions can be placed in an appendix and referenced in a short figure description. For example, provide a data table capturing the information in a bar chart, or a structured list representing a graph. For additional information regarding how best to write figure descriptions and why doing this is so important, please see https://www.acm.org/publications/taps/describing-figures/.

12.1 The "Teaser Figure"

A "teaser figure" is an image, or set of images in one figure, that are placed after all author and affiliation information, and before the body of the article, spanning the page. If you

Table 2. Some Typical Commands

Command	A Number	Comments
\author	100	Author
\table	300	For tables
\table*	400	For wider tables

wish to have such a figure in your article, place the command immediately before the \maketitle command:

```
\begin{teaserfigure}
  \includegraphics[width=\textwidth]{logo}
  \caption{figure caption}
  \Description{figure description}
\end{teaserfigure}
```

13 Citations and Bibliographies

The use of BibTeX for the preparation and formatting of one's references is strongly recommended. Authors' names should be complete — use full first names ("Donald E. Knuth") not initials ("D. E. Knuth") — and the salient identifying features of a reference should be included: title, year, volume, number, pages, article DOI, etc.

The bibliography is included in your source document with these two commands, placed just before the \end{document} command:

```
\bibliographystyle{ACM-Reference-Format}
\bibliography{bibfile}
```

where "bibfile" is the name, without the ".bib" suffix, of the BibTeX file.

Citations and references are numbered by default. A small number of ACM publications have citations and references formatted in the "author year" style; for these exceptions, please include this command in the **preamble** (before the command "\begin{document}") of your LaTeX source:

```
\citestyle{acmauthoryear}
```

Some examples. A paginated journal article [**?**], an enumerated journal article [**?**], a reference to an entire issue [**?**], a monograph (whole book) [**?**], a monograph/whole book in a series (see 2a in spec. document) [**?**], a divisible-book such as an anthology or compilation [**?**] followed by the same example, however we only output the series if the volume number is given [**?**] (so Editor00a's series should NOT be present since it has no vol. no.), a chapter in a divisible book [**?**], a chapter in a divisible book in a series [**?**], a multi-volume work as book [**?**], a couple of articles in a proceedings (of a conference, symposium, workshop for example) (paginated proceedings article) [**? ?**], a proceedings article with all possible elements [**?**], an example of an enumerated proceedings article [**?**], an informally published work [**?**], a couple of preprints [**? ?**], a doctoral dissertation [**?**], a master's thesis: [**?**], an online document / world wide web resource [**? ? ?**], a video game (Case 1) [**?**] and (Case 2) [**?**] and [**?**] and (Case 3) a patent [**?**], work accepted for publication [**?**], 'YYYYb'-test for prolific author [**?**] and [**?**]. Other cites might contain 'duplicate' DOI and URLs (some SIAM articles) [**?**]. Boris / Barbara Beeton: multi-volume works as books [**?**] and [**?**]. A couple of citations with DOIs: [**? ?**]. Online citations: [**? ? ?**]. Artifacts: [**?**] and [**?**].

14 Acknowledgments

Identification of funding sources and other support, and thanks to individuals and groups that assisted in the research and the preparation of the work should be included in an acknowledgment section, which is placed just before the reference section in your document.

This section has a special environment:

```
\begin{acks}
...
\end{acks}
```

so that the information contained therein can be more easily collected during the article metadata extraction phase, and to ensure consistency in the spelling of the section heading.

Authors should not prepare this section as a numbered or unnumbered \section; please use the "acks" environment.

15 Appendices

If your work needs an appendix, add it before the "\end{document}" command at the conclusion of your source document.

Start the appendix with the "appendix" command:

```
\appendix
```

and note that in the appendix, sections are lettered, not numbered. This document has two appendices, demonstrating the section and subsection identification method.

16 SIGCHI Extended Abstracts

The "sigchi-a" template style (available only in LaTeX and not in Word) produces a landscape-orientation formatted article, with a wide left margin. Three environments are available for use with the "sigchi-a" template style, and produce formatted output in the margin:

- sidebar: Place formatted text in the margin.
- marginfigure: Place a figure in the margin.
- margintable: Place a table in the margin.

Acknowledgments

To Robert, for the bagels and explaining CMYK and color spaces.

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[1] Keith C Clarke. 1986. Advances in geographic information systems. *Computers, environment and urban systems* 10, 3-4 (1986), 175–184.

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[5] Siddique Latif, Muhammad Usman, Sanaullah Manzoor, Waleed Iqbal, Junaid Qadir, Gareth Tyson, Ignacio Castro, Adeel Razi, Maged N Kamel Boulos, Adrian Weller, et al. 2020. Leveraging Data Science To Combat COVID-19: A Comprehensive Review. (2020).

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[7] Gustavo Niemeyer. 2008. Geohash. *Retrieved June* 6 (2008), 2018.

A Research Methods

A.1 Part One

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A.2 Part Two

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B Online Resources

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