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Considering innovations in cartography and changes in geographic representation methods

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Abstract:

Maps and map related objects are produced to represent geography. They range from paper maps to virtual installations, delivered using technologies that range from printing (traditional, on-demand and distributed) to the Internet (wired and wireless, desktop-facilitated and mobile). The underpinnings of the design and delivery of these representations are, and have been, linked to developments in theory and technology applied to the geosciences. These underpinning theories and technologies have been developed and applied throughout the course of the historical development of cartography and GI Science.

This paper provides the results of a research project that was undertaken to ascertain how different thinking about what constitutes an artefact can be used to communicate information about geography. It has defined and investigated the development of different approaches to the depiction of geography in four eras: 'Historical'; the 'start' of technology (1960s); the era of technological advancement (1990s); and the era of 'modern' technology. The paper reports on the findings, under these four 'era' headings and how cartographic artefacts have been employed for navigation, spatial analysis and the representation of 3-space + time.

Keywords: underground map, design, Melbourne

Introduction

Innovations allow successive generations to put their mark on a subject. Within cartography, this can be seen throughout the decades and centuries as new developments in technology have occurred and new purposes for mapping products have emerged. Each innovation provides an insight into the subject and also allows new opportunities for people to develop their own ideas. Mapping conventions have been broken each time that innovative people developed new and better solutions for displaying available data. Innovations in cartographic representation have not just come from cartographers, but from people in all fields of endeavour, who have seen a need and responded to it and it is these people who have contributed to the mapping industry as we know it today.

Hyper document approach

This research has been undertaken under a research design framework of a matrix that on one axis refers to the four eras: 'Historical'; the 'start' of technology (1960s); the era of technological advancement (1990s); and the era of 'modern' technology, and on the other axis, the three themes of navigation, spatial analysis and the representation of 3-space + time. In each of the 'cells' that this approach generated, specific cartographic artefacts that are considered to be exemplars of products produced in the certain era/use cell were chosen for analysis. This analysis is reported in the following sections of this paper.

The Historical Era shows that map design and products were being developed in different areas to provide the public with the maps (or map-related objects) they needed at the time. This may have meant discarding mapping conventions and/or creating a completely new product.

The 1960s saw the introduction of technology (particularly computer-based technology) to the mapping industry. Changes in this era show how the new technology and programs effected how products were created.

Technology also featured heavily in the 1990s, where the ideas and designs were expanded upon to create more products the public could use.

The current era (2000s) shows the access the public has been given to previously specialised software and datasets. There is also an emphasis on personalised mapping devices that are now an everyday essential.

Table 1 illustrates the products selected for each era/use cell.

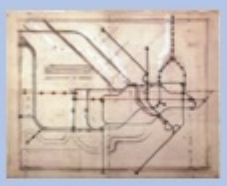
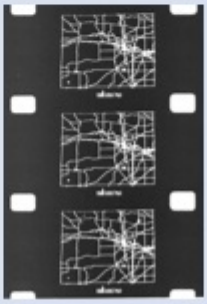
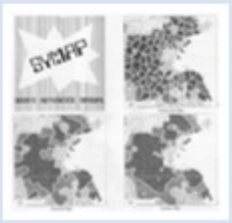
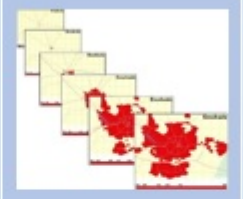
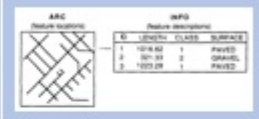
	Navigation	Spatial Analysis	3 Space + Time
Historical			
Start of Technology – 1960s			
Technological Advancement - 1990s			
Modern Technology – 2000s			

Table 1- Cartographic products and era/use cells.

Era 1 –
Historical - Pre 1960s

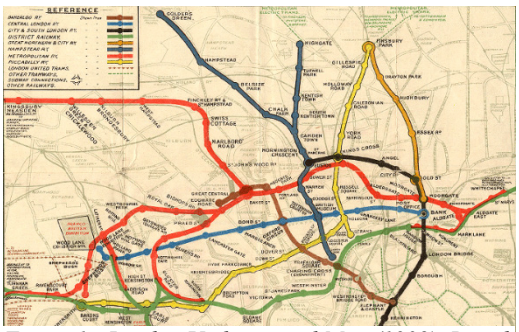


Figure 1 - London Underground Map (1908), British Broadcasting Corporation

The subjects for the historical era highlight the similarities of new innovations in cartography and the methods by which they were created. Harry Beck (Modern, 2014), John Snow (British Broadcasting Corporation, 2014) and Charles Minard (Cartographica, 2008) each showed how cartography could be seen and used in a different way and that general mapping conventions are not set in stone. The similarities between these three methods in particular is they all came in an era where digital technology was not involved in the process as it was an analogue era, revolving around hand drawn diagrams. Each 'designer' used their own knowledge and expertise to create usable products for the purpose they needed. In the beginning, the products available to them were not suitable for the purpose they needed which spurred them to design their own versions in order to show the information in a way they could use. Beck saw the deficiencies with the old Underground map product showing the geography above ground, while Snow needed a product that could be used for analysis of the spread of disease. Minard chose to change the common conventions of maps in order to show more information on one

diagram, allowing more connections to be made between the datasets. Each showed that, due to circumstances and the need for information in a certain way, new products could be produced.
These designs changed what people thought about maps, schematic maps, geo-diagrams and what they represent. The public, used to seeing one map design that shows a specific dataset in a certain way, sometimes see this as the only possible representation method. All three of these designers saw another way, a way of showing information in a better way than what was currently offered.

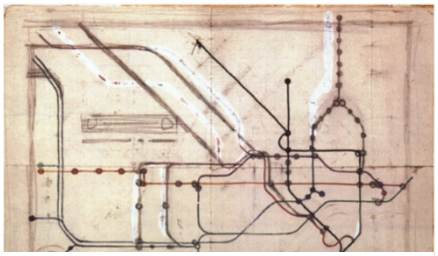


Figure 2 - Beck's Pencil Drawing Design of the London Underground, 1931, Victoria and Albert Museum London

Beck used his knowledge of electrical circuits to create a new technique when mapping the underground system. This use of electrical diagrams for representing underground train lines went against all conventions that used correct geographical position of lines and stations. Beck disregarded the precise geographical positions of the stations and, in doing so, changed the way all transport maps were created and understood. Abandoning geography was a convention that had not been seen previously as the underlying premise of cartography is that maps show true geography. Beck showed that adherence to true geography was not only unnecessary, but in the case of an underground system could be a hindrance to understanding the data portrayed.
Snow needed an innovative method to depict and analyse the spread of disease in an area of London and created his renowned cholera map. This map shows locations of deaths from cholera and the location of water pumps. By overlaying two data sets he was able to make connections between the disease and its spread. His analytical thinking showed that maps could be used as analytical tools to find answers that relate to geography. This was the start of analytical cartography and his method provides the information base needed to find answers to spatially located occurrences of deaths from this disease.

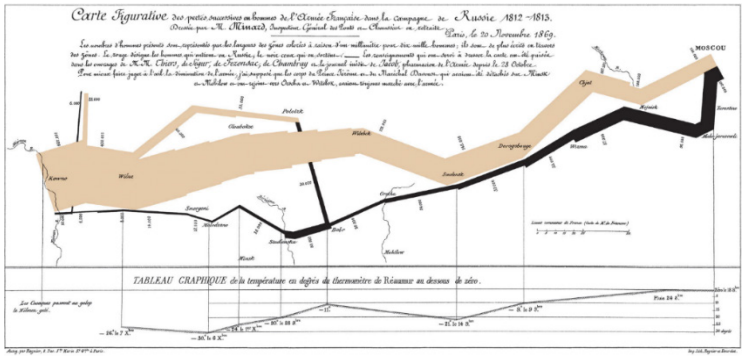


Figure 3 - Carte figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813, 1869, Cartographica

Minard used a schematic of geography in a way that had never been seen before. It showed multiple datasets on one axis and this provided more knowledge about the subject than one standard map could. He abandoned contemporary 'map' thinking and created links between the geographic data and other related information.
Analogue techniques connect these three innovations. The lack of automated technology meant their designs were painstakingly hand drawn to provide the details needed. This development through drawings shows their commitment to the creation of products that would change the way the world thought about representing geography. Each product illustrates their dedication to showing information in a better way, so that it could still be understood, even though it did not necessarily follow normal conventions. From this, new conclusions could be made about the data shown.
Snow's work with Cholera proved that the disease was water-borne and not air borne, as was thought. This map had a huge impact at the time. This analytical approach still works today to help monitor the spread of other diseases, albeit using contemporary GIS.
Beck worked in the underground drawing office for years and developed his idea in his spare time. His patience and dedication to his design eventually bore fruit and the map was published by London Transport. His underground map shows his commitment to make the design work and not letting negativity stop the progress of his quest to provide a better solution.

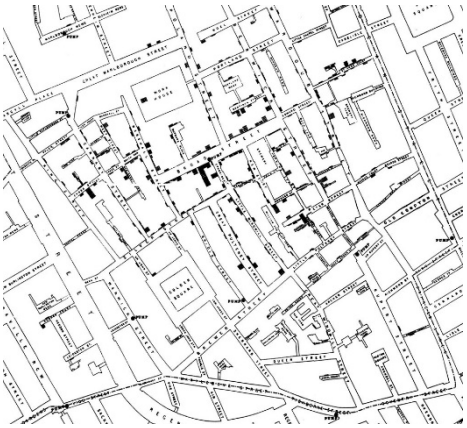


Figure 4 - John Snow's Map of Cholera in London, 1854, University of Delaware

Minard used analogue techniques, and basic printing methods and drawing, which were the only methods that were available to him to create his product. He used them in a successful way to produce the designs we see today.
The three designers for this historical era, although none were professional cartographers showed that conventions could be broken and that alternatives to conventional maps could show however much or little data as the producer wanted. These innovations allowed future map designers to expand their thinking on what was 'conventional' and what type of products could be produced as useable alternatives. The world embraced these designs as they brought something new to spatial analysis and data representation. They were also products that could be and are used to provide geographic information to society.

Era 2 Technology – 1960s

The 1960s in the spatial industry was one where technological development started. The technology to be able to do spatial work digitally was just beginning to have an effect on the industry and this was the start of a new era in the way products were developed. The very early application of technology for creating information products started in universities and the professional sector. This allowed up and coming professionals to develop new ideas of how the technology could be used to produce new mapping designs and alternatives to those in use. The development of technology such as the Harvard Lab (Charting the Unknown, N. Chrisman, 2006) meant that students would be the ones to take the new innovations and create new theories and methods. These methods would eventually become the methods taught to students and become the industry standards. This technological development included an increase in usable interfaces and better programs coming from computer graphics that could be used for spatial data. This era showed that people were thinking differently in terms of spatial data and how it could be represented. The computer systems were in place; however there were no specific programs for spatial data and this was the technology that was developed. In this era, ways of storing the data as well as accessing it and displaying it in a usable fashion were developed. The technology was available; however it required different thinking w.r.t how to use it, in order to show geographical information. The technology allowed innovators such as Roger Tomlinson (UCGIS, 2014), Duane Marble (UCGIS, 2014) and Peter Burrough (Goodchild, 2014) to use other conventions for spatial analysis described by Ian McHarg (J Corbett, 2014) and convert it into digital format. The technology triggered a launch from analogue to digital spatial analysis and launched today's systems.

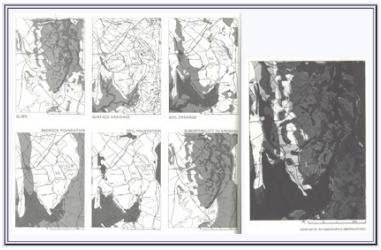


Figure 5- Examples of Overlays, 2000, A. Whiston Spirn

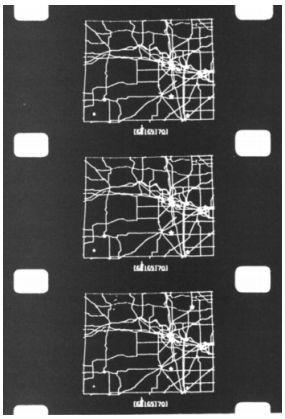


Figure 6- Stills from the Ann Arbour Traffic Animation, 1976, H. Moellering

Technology also allowed data to be shown in different ways, drawing new conclusions from available datasets. Harold Moellering (Ohio State University, 2014) showed this with this research into using animation to show information over a long time period. His work showed that animation, which at the time was used for entertainment, could be utilised in other areas for informative and analytical purposes. This era was about using the technology and resources available and creating something new from them, by using them for purposes for which they were not originally designed. Moellering showed that by using this technology, new trends in the data could be seen more readily, particularly identifying where accidents were happening in specific areas at certain times of the day or week. This provided a clearer picture about the safety of the area in terms of traffic accidents and has been used since to show these types of incidents.

Figure 7 - Melways First Edition, Section of Map 43, 1966, Melway

Design ideals and conventions were another part of this era and it was how they were being broken that again highlights innovations in design. From the historical era, where each disregarded a convention, the designers of mapping products were still experimenting with the use of different conventions and what was and wasn't needed. The Melways (Australian Institute of Cartographers, 1981) showed this by their use of single line representations of roads. They ignored the normal convention of showing roads as a double casement and chose the new representation. It was thought at the time to be a mistake, however the design was popular with the users, the driving public, and this design became the 'new' convention. By a simple change of design, new conventions can be made.

The Melways also showed the new technology was not always necessary, with the street directory still being produced through analogue processes. By doing the work by hand, accuracy could be checked regularly and updated when necessary. The technology throughout this era showed the beginnings of geographic information systems, but fully functioning systems were not available to everyone, as they were extremely expensive.

The progressive thinking by all these spatial analysts, fathers of GIS and cartographers, once again pushed the boundaries of what was the norm for displaying spatial information. The new program developments and new techniques for showing data moved the industry forward to a new era. This was just the beginning of linking spatial information and technology and would be the start of today's industry.

Era 3 – Technology Advancement – 1990s

The 1990s was the era where Geographic Information Systems (GIS) rose to prominence. The 1990s saw technology become accessible and affordable, and an everyday 'essential'. GIS also grew with the rise of personal computers. The need for electronics and technology in everyday life fuelled the desire for newer and

Figure 8 - Whereis.com's Webpage, 1999, Whereis

better applications. GIS went from being a specialised software program that could only be used by professionals, to products available to those who needed access to them.

As everyday electronics became widespread, spatial data and spatial information products became easier to access and use. Computers, dial-up Internet and mobile phones were just some of the products available and they bridged some gaps in terms of information access and sharing. Environmental Systems Research Institute (ESRI) was one of the first companies to provide a product that could be used by both the professional (in the industry) and the public. *ArcInfo* (ESRI, 1992) was this product and it allowed GIS to become more accessible and usable. Another factor making for better accessibility was data availability. As the GIS industry was fairly new, data was everywhere but the issue was how to gain access to solid datasets. With access to some spatial information, the public wanted more. It demanded more information from the Internet, as well as general upgrades to software availability. Whereis.com provided the public with access to spatial information and provided an 'upgrade' from what was previously an out-of-date street directory. The Website provided access to data with which people could plan their journey on-screen.. It provided location and other information digitally, which helped feed the need for up-to-date information. This, however, created an almost unrealistic expectation from the public about accuracy.

Location Based Services (LBS) was a big development throughout this era. It saw the start of multiple websites and device developments to satisfy the public demand. It was a relatively new source of information that had not been seen before. Companies such as Navteq provided the spatial information that was desired, accessed digitally and online. There was an expectation that the data provided would always be the latest and most up-to-date data available. This was unrealistic as it took time to gather new data and process it, before putting it on any type of spatial information-based website. Due to this relatively new information source, this was an issue that needed to be addressed. This led into other areas of mapping and data such as *ArcInfo,* where the public accessed data from any source, expecting it to be accurate.

Figure 9 – Stills from Enschede's Town Growth Animation (800AD-1998), 2002, P. Ogao

Menno-Jan Kraak (University of Twente, 2014) is a geospatial professional who challenged conventions once again. He developed new techniques for using animation to show datasets in a different way – adding time. He used this technique to develop new theories on how time and information could be used to explain changes in the environment. This was a continuation of the work Moellering (Ohio State University, 2014) undertook in the 1960s. Better methods were created and animation became another available tool for spatial analysis. *ArcInfo* also showed progress in the industry, as it used an older technology and made it relevant to what the industry needed at the time. The upgrade in technology and spatial software provided more public access, which in turn provided more exposure of the industry to the general public.

The 1990s was an era that showed how technology was able to bring cartography and spatial information to the public. It allowed it to go from a specialised profession to something that the public could understand and access. While computer programs allowed the public to do this, they were still complicated and the need for background knowledge was still great. Programs were more usable than in the past decades, but most of the newer programs were still command-line driven. This required detailed knowledge of the program and how it worked in order to be able to create usable products. The 1990s also showed that geographic information was becoming more necessary in everyday life and was a need that would only grow as the technology to gain access to that information grew. This was the start of providing more spatial data and products to the public and expanding the GIS industry further.

Era 4 – Modern Technology – Post 2000s

Technology and instant access to information is an essential and expected part of modern day life. It is this that has continued to fuel the spatial industry. With more personal devices than ever, the information that is needed to feed the public is immense. With over 1 billion sales in smart phones worldwide in 2013 (International Data Corporation, January 2014) and new spatial programs allowing the

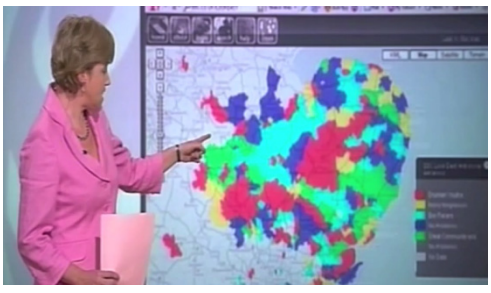


Figure 10 - Snapshot of BBC's Looking East Program Map, 2010, A. Hudson-Smith (Youtube)

public to gain more information about their surroundings, the need for more up-to-date information is paramount. Datasets are now more accessible than ever to both industry and the general public. Another issue that needs to be considered is the sheer volume of spatial data being created and shared, together with the accuracy and reliability of that data. Which sources are reliable?

Andy Hudson-Smith (Centre for Advanced Spatial Analysis, 2014) is one person who has shown that the new technology can be used to produce information using data from the public. He uses crowd-sourcing (Centre for Advanced Spatial Analysis, 2014) to show the mood of each suburb about a certain subject and relies purely on user participation. This provides an almost instantaneous dataset. Crowd-sourcing is a new way of collecting data; however it is an unreliable one in certain ways as it is mainly opinion based and might not be as accurate as some other sources. Crowd-sourcing can however be a valuable source of information. For example, the 2010 Haiti Earthquake utilised crowd-sourcing to help the people affected on the ground know where medical help was available and where shelters were.

There is a wide range of data available from this type of information gathering. The program that Hudson-Smith has created shows the public's opinion, however it cannot show much else other than an opinion based poll. The spectrum of data that can be collected is broad; however it is the accuracy that is in question.

Online GIS (GIS Cloud, 2014) also has a similar problem as it can be used by anyone with any dataset and can be manipulated to show any point of view. The technology, especially with Online GIS, has become a lot easier to understand and use, making it easier for the public to create maps and put them online. While online programs have given more of a name to GIS and the spatial sciences their use raises some concerns. Originally, GIS was used by trained professionals. Nowadays GIS is in the public domain allowing anyone to create products for their own use. This is an issue where the public, often who don't use products such as Online GIS, believe that a map is always correct. With Online GIS, it is impossible to regulate map making and map manipulation. Both crowd-sourcing and online GIS has brought spatial information products to the public in a more interactive way than ever before and provided enough of a learning base that the public now understand the industry more than in the past.

Figure 11 – Garmin Nüvi 65LMT, 2014, Garmin

While the mobile industry has increased, so has the use of personal location devices (PLDs). In 2011, Garmin sold nearly 16 million devices and with nearly 98 million devices sold since the company's inception in 1989 (Garmin Annual Report 2011) this shows that personal devices are extremely popular and a valued everyday item. This location based technology has grown from a website to devices for in-car navigation as well as in smart phone programs and apps. This connection to a location service has grown immensely and some of the technology has been subject to scrutiny regarding the issue of privacy. These devices have the ability to track movements and that data can be available to the companies that produce the devices. In a world where everyone has a smart phone or a GPS unit, this is an issue that needs to be addressed.


Figure 12 - Example of Google Maps StreetView, 2014, Google

Privacy is the main issue with the influx of new technology and being able to put information and data online. Crowd-sourcing relies on audience and public participation and allows the user to not participate. It uses common postcodes in order to group the data without asking for specific address information. This protects the privacy of the participants while still letting them have an opinion on the subject. These sorts of issues didn't exist previously as the technology to gather information didn't exist. Google maps and other companies use camera cars and flying drones to collect spatial information which moves into a problematic area in terms of privacy laws and how far companies will go to get data. Spatial data can be gathered from many sources but it is their credibility for the chosen subject that is the main issue. There are many more opportunities for the industry to grow, with the technology still evolving into more powerful and useable devices. The spatial industry will continue to grow and map more of the world than ever before as it evolves and becomes more sophisticated.

Navigation

Throughout the navigation stream, there is a clear progression in the techniques and products that are created and used. All have in common that they are navigation tools for personal use and are still used today. It is a section of the industry that has been relevant since the beginning of map making, where maps were purely navigational references. Usual mapping conventions show that not much changed in map design.

Beck was the first example of a change in mapping convention where he disregarded geographies. His work showed that true geography didn't always have to be maintained in order to give the required information. By using his knowledge of other drawing configuration (electrical diagrams), he was able to design an easier to understand design that didn't keep to normal conventions. This was originally declined by his employer; however they were persuaded to give it a try. This was the start of a new way of mapping and showed that people outside cartography can have a positive influence on conventions.

The Melways also disregarded normal cartographic conventions when they changed how roads were shown. Again this was pushed aside and ridiculed to some degree until it hit the shelves and was a success. The change in standards showed that it was often the case that the cartographers were trying to show too much to the public when all they needed was to be able to get from A to B as easily as possible. Simplicity worked for street directories and showed that different representations can work just as well. The change in design proved that innovations were still happening in cartography and design could still make a big difference in how a product was received by the public.
Web cartography was the next step in the evolution of navigational cartography. Cartography and mapping products were produced as online products for the public to access from their own devices. Whereis.com was one of the earliest companies to enter this part of the industry, putting their mapping products online. It allowed the public to gain access to more up-to-date maps in comparison to the previous method of using a street directory which was updated every few years. Cartography progressed as technology improved and showed it could evolve to keep up with the needs and wants of the public.

GPS became the latest device in personal navigational technology and since the turn of the century its use has grown immensely. Garmin are one of the biggest companies producing these devices having sold more than 98 million units (Garmin Annual Report 2011). GPS devices or Personal Location Devices (PLD's) replaced street directories (to a large extent) and other means of location finding. PLD's have become common place as they direct the driver to where they wish to go on a pre-determined route. This changed how navigational products were used again. It illustrates how mapping could be made accessible and has evolved through the application of technology.
Mapping has progressed from paper based to digital and this has created some problems within itself. In the past when mapping was paper based, there was the understanding that the maps would eventually be out-of-date and then a new updated version would be needed. Now with maps delivered using technology, there is the belief that the maps are always correct and current. This is a common mistake. However it can be the cause of multiple problems such as PLDs not knowing about diversions or new roads that may that provide a quicker and easier journey. The expectation of having correct data all the time is one that cannot be changed without the public gaining more knowledge about this data, how it is processed and delivered.

Technology has allowed navigational cartography to evolve and expand, making access to mapping products an everyday expectation. The industry has grown and changed from paper mapping to technology based products. Technology is the driver that allows navigational cartography to develop, providing geographic information where and when needed.

Spatial Analysis

The use of mapping products for analysis has always been part of mapping. Maps were commonly used for navigational purposes, but many found other uses for them for depicting other data types spatially. This allowed users to analyse spatial relationships between different datasets.

John Snow was one of the first to use spatial analysis and use it to draw conclusions and prove a hypothesis. He plotted the deaths from cholera on a map as well as other features such as water pumps and used spatial analysis to draw conclusions about how the disease spread. His method of marking each death with a dot at a specific address has been used within and outside the medical profession to show a range of epidemiological data. This method provided a visual summary of written information. Once displayed, Snow could confirm his theories. This method is still used today to depict the spread of disease and is a basis for many different spatial information products.
Harold Moellering used technology to show spatial data in a different way, and a new way in terms of spatial analysis. His use of animation and spatial data allowed a new variable to be added to the mix. He added time to other variables and by doing this, once again, allowed new patterns and conclusions to be drawn from the data. The animation showed the number of car crashes in the town of Ann Arbour, USA and as the animation played, it showed the time element. This provided information on any patterns that weren't picked up by the original stills of data before it was put into the animation. Moellering's use of technology in providing more information and analysis from the data showed how technology could be utilised to produce better information products.

Menno-Jan Kraak used advances in technology and Moellering's animation concepts to provide new insight into town planning and growth. Kraak used animation to create spatial information products that showed how the town of Enschede in the Netherlands expanded and grew. His analysis revolved mainly around the public transport network, determining if it was built before or after the town's population spread. Kraak continued to work with animation in order to expand the knowledge of how these tools could be used for spatial information representation and analysis. Animation provided a platform where time specific data could be shown. His work reiterated Moellering's work and showed how animation and mapping could be a powerful tool for spatial analysis.

Andy Hudson-Smith's work with *SurveyMapper* and *MapTube* show how the public are now more involved than ever with mapping. Hudson-Smith used crowd-sourcing as a method of gathering data and information for analysis. As part of the BBC's 'Looking East' Program, Hudson-Smith was able to provide a method that allowed the public to have their say and see the results during the broadcast. The technology now available to the public allows them to provide information to create useful datasets. The technology allows information to be gathered from around the world and be shared. Hudson-Smith utilised the public's desire to provide information and their opinions. The technology gave them the way to provide it, in order to get almost instant data on a specific subject. This data is raw and circumstantial, however the methodology shows that spatial analysis can be made available in a multitude of ways.
Throughout this area of study, the main contributor to this development is technology itself and its uses. As the technology developed, people saw ways to use it for alternate purposes allowing for new products and techniques to be developed. As technology continues to evolve, the way spatial information products are produced and used for analysis will continue to evolve as well.

3 Space + Time

Spatial information consists of a multitude of data and information that allows the user to see connections between the datasets. Space + time are variables that are seen most often. The techniques in creating specific data products to show 3 Space + Time have developed around technology, much like the other themes discussed. Technology over the years has supported growth in this subject area and promoted change from being a much specialised discipline to one that can be used by many people with different backgrounds.

Charles Minard put multiple datasets on one spatial information product in order to show all the relevant data in one place. His '*Carte figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813'* (1869) is one of his best known products. It pushed the boundaries and conventions that were seen in the industry at the time. He used multiple datasets on one diagram to show Napoleon's March into Russia and his retreat which brought together datasets in order to make connections between data sets. He used temperature, number of troops, altitude, location and battles that occurred along the way. His way of illustrating this data showed where Napoleon lost troops and why - whether it be in a battle or due to the freezing temperature. The way this data is shown has a profound effect on those who cannot comprehend the number of troops. Minard's use of spatial representation removes normal conventions in order to give more information to the user. This representation allows the user to make connections themselves and explore the information provided.

In the 1960s, Geographic Information Systems (GIS) were in the early stages of development. The technology was available to start building a spatial program for computers and to be used by industry. It was a specialised program as the technology was not readily available to the public. The technology existed, but the purpose- built GIS program still need to be developed. In the end, GIS used a specialised database in order to store and apply data. The entire system relied on a database in order to function. The computer technology allowed GIS to go from an analogue paper layer system as designed by Ian McHarg, to a digital system where the data could be changed. The 'fathers of GIS' wanted to develop software that allowed the data to be manipulated and studied as necessary. This development showed how the industry would move forward with technology.

The increase of spatial companies with programs continues from the start of GIS in the 60's to today where hundreds of programs are available for sale. Esri is one of the biggest contributors to this industry and one of their first programs, *ArcInfo*, became a turning point for easily accessible spatial software. Up until products like *ArcInfo* were released, spatial technology was still a specialised area, with the public not having complete access to the same software as it was expensive and required an advanced computer system to operate. It was available, however as not many people understood what it could do, not many, apart from professionals, wanted to use it. This program still needed to be used by someone with a specialised knowledge. Knowledge such as how to use command-line and the terminology needed to make it work allowed the user to create products almost automatically. Technology was again the main driver through these few decades as the programs became easier to use and more accessible.

In the modern era, technology and information are a must in everyday life. Data is more available than ever before and the public want to be able to use this to create information products of their own, including geospatial products. The industry has evolved to the point where online GIS is available and the programs are now at a level where anyone can use them to create a product. The technology does not require a detailed background knowledge on how it works and, as it has become easier to use. This has helped broaden the industry. Technology has allowed GIS to become an online asset and has encouraged data sharing and product generation, globally. From here the industry can continue to expand and be introduced to more of the general public, who can in turn expand their own knowledge of cartography and its potential uses.

Conclusion

Methods applied by cartography for representing geographies will continue to evolve as outside influences on the industry and products change. There are already examples of changes in the industry as the technology gives the public better and easier access to information and data, such as *Google Glass* (Glass, 2014) and Wikitude Navigation

(Wikitude, 2014). Both these products are integrating new ideas for spatial information with technology and are rarely seen. Many predict that these types of products will become more popular as the technology becomes more affordable. Developments will continue to occur with influences from both inside and outside the industry as technology and public knowledge about spatial information grows and develops. The future of cartography and new representations of geography continues to be influenced by the outcomes of explorations of the available data and the creation of innovative, technology-produced and delivered products.

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