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High resolution air quality and urban design

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Respiratory and neurological diseases in children such as asthma and air born chemicals have been linked together by health specialists in Europe and the United States [17] [16]. The impact of these findings in cities suggests not only knowledge of air quality but small-scale geospatial understanding of public space. High resolution air quality in the public space, where child as sensitive members of society pass through, play, eat and learn, goes mostly unmeasured at the small-scale. Most US and European cities possess fewer than five active air quality stations for particulate matter, PM. This research investigates a geospatial analysis tool and sensor device measuring at the small scale of suspended particles PM 2.5 and smaller PM 0.5 micrometers with urban design characteristics. Measurements are taken along sidewalks in Barcelona's Eixample neighbourhood at 33m and Portland's Pearl neighbourhood 100ft increments. The study uses expertise in computing, urban design and the health sciences to empower behavioural change.

Keywords: design evaluation, urban design, design informatics, design methods, geospatial information systems

1 Introduction

Unborn, new-born and young children's physiological development may be significantly affected by the air quality in urban environments. Respiratory and neurological diseases in children such as asthma and air born chemicals have been linked together by health specialists in Europe and the United States [17] [16]. Investigating this problem requires not only knowledge of air quality including suspended particles but small-scale geospatial understanding of urban design characteristics in public space such as building heights, street widths, transit routes and green spaces. The air quality in the public space where these sensitive members of society pass through, play, eat and learn goes mostly unmeasured at the small-scale of urban design characteristics. Is a park within the interior of a city block safer than a street with high traffic? Does the location of a pre-school along a busy street with multiple lanes of dense traffic lead to higher PM levels in front of that school? Most US and European cities possess fewer than five active suspended particle PM air quality stations making it impossible to understand the implications of human scale urban design decisions from planners. Stake holders such as parents also do not have information at a resolution level high enough to make informed decisions at the scale of the spaces in which they live.

This research investigates the creation of an affordable handheld robotic instrument and geospatial analysis tool to understand the impact of suspended particles PM 2.5 and smaller 0.5 micrometers with small-scape urban design characteristics at the human street level experience. Measurements are taken along sidewalks in Barcelona's *Eixample* neighbourhood, and in Portland, Oregon's *Pearl* neighbourhood at 33m increments across standard 100m blocks in a three x three block test area. The test area of three by three block area in Barcelona and equivalent are in Portland was chosen because it represents a new urban unit called a *superilla* [20] in Barcelona intended to create liveable complex urban ecologies [18]. The study uses expertise in urban robotics using custom sensors and microprocessors to create a mobile sensor device, urban design tools using parametric workflows and epidemiological understandings from collaborating experts in health science and air quality. This socio-computational workflow and incorporation of computation and urban design contributes to a new understanding of urban ecology [14] that investigates cities as dynamic organisms of multiple integrated systems. Urban ecology is supported by a parametric approach to geospatial information systems, GIS, allowing the integration of multiple layers of different information. A coding method to organize and translate qualitative information such as the air quality into geometric and visual information is now available to empower urban planners to understand the broad and complex relationships present in urban design and for local citizens to make informed behavioural changes on the ground from the bottom up.

2 Background / Contextualization

2.1 Identification of sample air quality criteria

Existing air quality stations are located around the cities of Barcelona, Spain and Portland, Oregon, measuring various characteristics of air pollution. Locations are often obscured but their location and data may often be found via online data portals that display information in geospatial map format [1]. The identification of a first air quality characteristic to measure and analyse air pollution began by researching the following comprehensive list of US EPA criteria publically accessible via web-based maps of major cities [1]:

- CO
- CO2
- Lead - TSP (LC)
- Lead - PM10 (LC)
- NO
- NO2
- Ozone
- PM10
- PM2.5
- SO2
- PM2.5 (limited)
- IMPROVE - Interagency Monitoring of Protected Visual Environments
- NATTS - National Air Toxics Trends Stations
- NCore - NCore Multi-pollutant Monitoring Network

A subsequently interview with respiratory health expert Jordi Sunyer at the Centre for Environmental Research in Barcelona helped to identify suspended particles PM 2.5 as effective characteristic effectively measured at the small urban scale of human space. According to Sunyer and other scientists, particulate matter, PM, provides a street level pollution level with significant impact on humans, with contributions especially from automobile combustion, disc brakes and rubber tires [25]. A small mobile device to measure PM around Barcelona did not exist. In 2006 Barcelona's annual average PM count was 50µg/m^3 with OMS recommendation not to exceed 20µg/m^3, according to the World Health Organization [28]. The consequences according to this study suggest a possible increased cause of asthma and bronchitis in children [17]. It was concluded with Sunyer that the measurement of PM10 and PM2.5 was important for the impact of people and that a way to measure the high resolution ground-level measurements of PM was needed via an inexpensive and or mobile device.

Table 1 Concentrated PM10 observed in world cities, World Health Organization, OMS

Tabla 1.1. Media anual de las concentraciones de PM_{10} observadas en algunas ciudades del mundo

Continente	Ciudad	Media anual de concentraciones de PM_{10} ($\mu g/m^3$)
Asia	Nueva Delhi	160
	Seúl	60
	Tokio	30
América Latina	Lima	110
	Ciudad de México	55
	Sao Paulo	49
África	El Cairo	150
	Ciudad del Cabo	25
Europa	Praga	60
	Barcelona	55
	Roma	55
	Oslo	45
	Londres	25
	Estocolmo	20
América del Norte	San Diego	50
	Los Ángeles	48
	Nueva York	25

Fuente: *[9] OMS. Directrices sobre la calidad del aire. Actualización global 2005.*

2.2 Scale of measured criteria: urban design and computing context

Suspended particles go unmeasured at the small-scale of public space related to the urban form of streets and blocks of buildings, the land use of parcels and transportation such as bus routes, bike lanes, the number of lanes of traffic and pedestrian paths. Manhattan, New York, for example, has only one active PM sensor located below Canal Street [1]. In Portland, Oregon, only one active sensor exists within the urban growth boundary [1]. One PM sensor exists in the *Eixample* study area in downtown Barcelona [9]. The investigation focuses on the street level variations of PM level, seeking to understand and have expected outcomes that the dissipation of PM is unlike air qualities such as ozone and CO2, as stated by Sunyer. As such measurements of PM would be taken in public space to understand variations within and between street right-of-ways, varying significantly from one street to the next. To gather this differentiation of data the mobile and inexpensive handheld device would be needed to map data within a street and block scale. PM measurements were thusly take at street level locations at 33m increments in walking along the centre of city sidewalks. 100 x 100 meter long *Eixample* blocks in Barcelona were measured at twelve locations and 200 x 200 feet long blocks in Portland were measured at eight locations, providing a similar spacing of data to compare these two cities. The resulting collection of data points would create an evenly distributed map of information – uninfluenced by presumptions of use.

Conceptually, the street-level measurements in Barcelona and Portland were used to sense the city [11] [25] and to complement traditional top down formal urban design strategies such as street grid structure and land use locations. The everyday street-level experience of time-based *phenomenon* may be measured [15] and urban activities may emerge that adaptive 'loose spaces' in cities [4] that are not completely planned from the top down such as defined street and building locations. Carlo Ratti's MIT's SENSEable Cities lab has been a leader in the urban computing field to understand various ways to access information at the small scale human experience in cities [12] differentiating the types of data used to map information across cities and regions. Their work investigates the human small scale geospatial understanding explored in the research published here, for example, tracking the waste recovery chain of recycled materials [12]. The small-scale and time-based phenomena of air pollution described in this paper would require a dramatically smaller 33m measurement versus the existing informational maps today that show one measurement per district in the existing cases of Barcelona and Manhattan or one sensor in all of Portland.

The research presented here build on one of the author's previously developed high resolution mapping technique for three by three block areas in Barcelona, taking measurements at the centre of sidewalks in public right-of-ways at 33m increments [24]. This mapping methodology allowed the identification of variations, *or parameters*, in the urban environment and measurements that included building heights, open space, adjacent traffic lanes, bus routes, bicycle lanes, landscaping buffers such as trees and low shrubs and urban furniture. Important understandings of that previous work included new workflows of geospatial information in 3D parametric software and the flow of information collected both on site and off site using tabular spreadsheet codification.

Other existing methods and tools to measure air pollution include a network of everyday citizens such as "Smart Citizen" [7] that look to provide multiple sensors to individual citizens and capture a less defined and more emergent geospatial pattern of human activity – not focused on young urban dwellers and not using the *superilla* scale of three by three block areas which is becoming an important urban unit in Barcelona. Another air pollution study at the neighbourhood scale is being studied in Portland, Oregon focusing on registered air pollution contributors by Richard Beckwith of Intel Labs [30]. In this case the specific location of air pollution devices is informed by the suspected sources of pollution rather than an equally distributed grid of data points. The location of their data points is more prescriptive and informed. The objective of the research presented in this paper unlike that work was to spatially understand emergent patterns of various urban characteristics, rather than basing data measurement on prescribed pollution sources.

3 Analysis and Contribution: High Resolution Urban Sensing Methodology

The research question that most clearly describes the work done here is how to collect, measure, analyse and visualize PM air pollution and the human scale relationships of urban design. To create a high resolution geospatial understanding of PM air pollution a parametric modelling approach was used combining: 1) a PM sensor device measuring geo-locational data points and 2) a table-based mapping organization to analyse and visualize various urban design data types. The iterative design method [29] alternating between mobile sensor device specifications and parametric GIS mapping work allowed the two approaches to inform one another. Multiple iterations of each phase were done and evaluated to inform revisions and improve results. The result was a new and integrated methodology as an alternative approach to fixed locations of costly air pollution stations.

3.1 PM Sensor

Sensor device development began with a custom assembly of inexpensive equipment, with consideration of sensor accuracy using protocol using inexpensive sensors to identify major changes in PM level and later using more expensive sensors to confirm even finer resolution of changes of data. A Sharp Optical Dust Sensor [23] with an Arduino Uno and later USB connected with a Raspberry Pi were used with the objective to produce an affordable mobile geolocation point sensor for PM 2.5. A python script was written to process the PM concentrations and sound measurements. The work targeted a 0.5 micrometer concentration of PM that is more accurate than PM 2.5 US EPA standard. A GPS module was used to add latitude and longitude data. An LCD display was added to verify data sent via WiFi module in CSV table format. An SD secure digital card was used to record data.

The sensor device was designed to take measurements at the 33m point increments first assigned via a My Places Google map with 108 pin locations and exported from KML to CSV format. The device used a 'butterfly net' technique walking along the centre of sidewalks within a one-meter tolerance of the 108 points to capture data (UAV for future tests). At each point location ten measurements were taken and averaged by an algorithm loaded into the Arduino. The Raspberry Pi was used to process data to a CSV file for both PM and noise data collection for all108 points. Future techniques are being explored to increase the automation and accuracy of data collection including the use of building addresses and variations in data capture sensitivity to make possible collection via bicycle. These future considerations would enhance scalability that informed the parameters of cost effectiveness to ensure a high impact of the future use of this methodology.

Data measurement was taken at three levels: 0.1m above the ground, inhalation level at approximately 1.5m above the ground and at 5m above the ground to analyse differences in urban design characteristics and PM level. A helium balloon is used for the sensor 5m above ground connected via a line-weight, six-wire cable. A wi-fi module is being developed for future use. A third Sharp Optical Dust Sensor was hung to 0.1m above ground level. It was important for the time-based data that the sensors located at various heights to record data at precisely the same time to avoid environmental differences of atmospheric phenomena. A more comprehensive mapping of the three dimensional information was not done that the time of the research but is planned. Dylos 1100 and 1700 sensors were later added to the work. The performance of these sensors has been published with relatively high levels of accuracy when compared to peer devices within this price range [27]. The use of this device was added to the methodology to help calibrate the less expensive Sharp sensor.

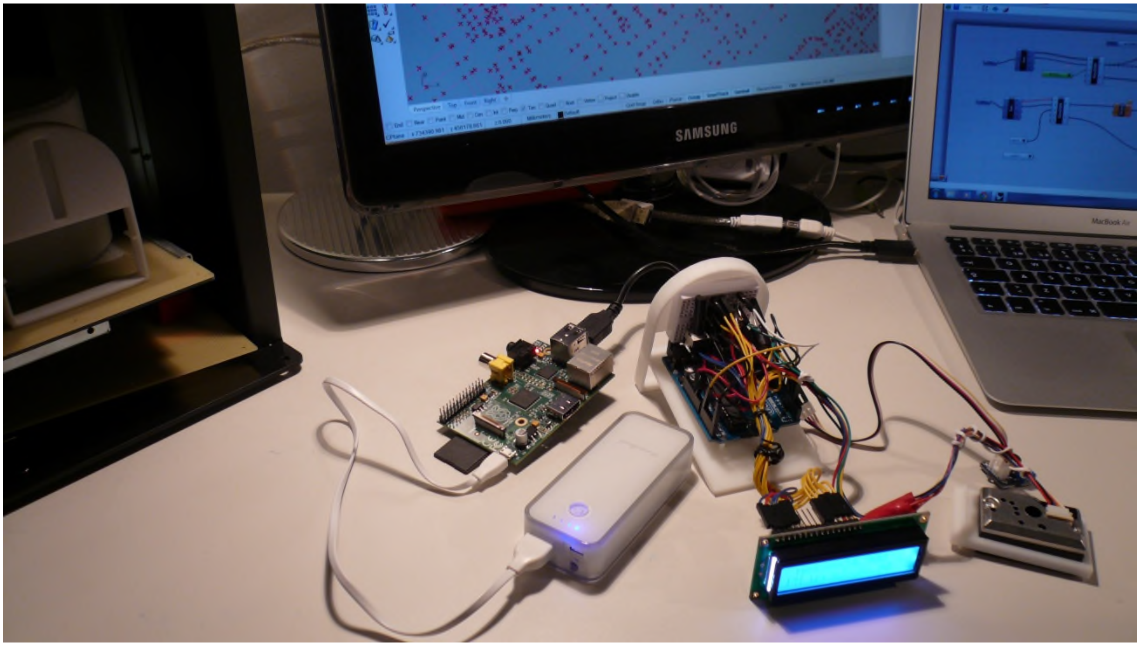

Figure 1 PM sensor device assembly

3.2 Geospatial Information, GI, Urban Analysis Tool

The objective of the GIS work was to use newly acquired and custom formulation of geospatial data. The research data of PM and sound were analysed and visualized geospatially using Rhino Grasshopper 3D software [21] with GIS plugins and custom scripting. Traditional planning geospatial information systems software such as ESRI ArcGIS [15] use table based data including latitude and longitude but use existing data bases called shape files, often assembled via municipal datasets, and are less accessible to custom formulation of data. The research method described here used Rhino Grasshopper with two basic plugins and scripting: 1) ELK plugin [10] using open street maps files in OSM format with existing building, highway, bike and rail data and 2) HUMAN plugin [6] using CSV files with data including latitude, longitude and other quantitative to visualize qualitative data in the 3D environment . Output visualization of the tool included coloured underlay maps, a series of lines in the z-vector direction, a surface topography and curve defined topography. The intended outcome of the visualization was to analyse the high resolution of differences in PM and sound levels against three dimensional data of urban design characteristics.

A test area in Barcelona was selected. Kept in mind were the forthcoming *superilla* three by three block areas. As previously mentioned the objective of this study, unlike the Intel study in Portland for example, was intended to identify emergent urban characteristics and their spatial relationships to the data. This informed the criteria used to select a three by three *superilla* within the *Eixample* district test area and included:

- Regularity of the city grid (100m square)
- Regularity of the urban wall

- At least one public open space at block centre
- Regularity of the public right-of-way
- Variations in traffic lanes, bus routes and bus shelters, bike share and bike lanes

Figure 2 demonstrates the regularity of the urban form with a well-defined urban street wall and the inclusion of a public park at one of the patios, for pedestrian access and for the research team to measure data at this location.

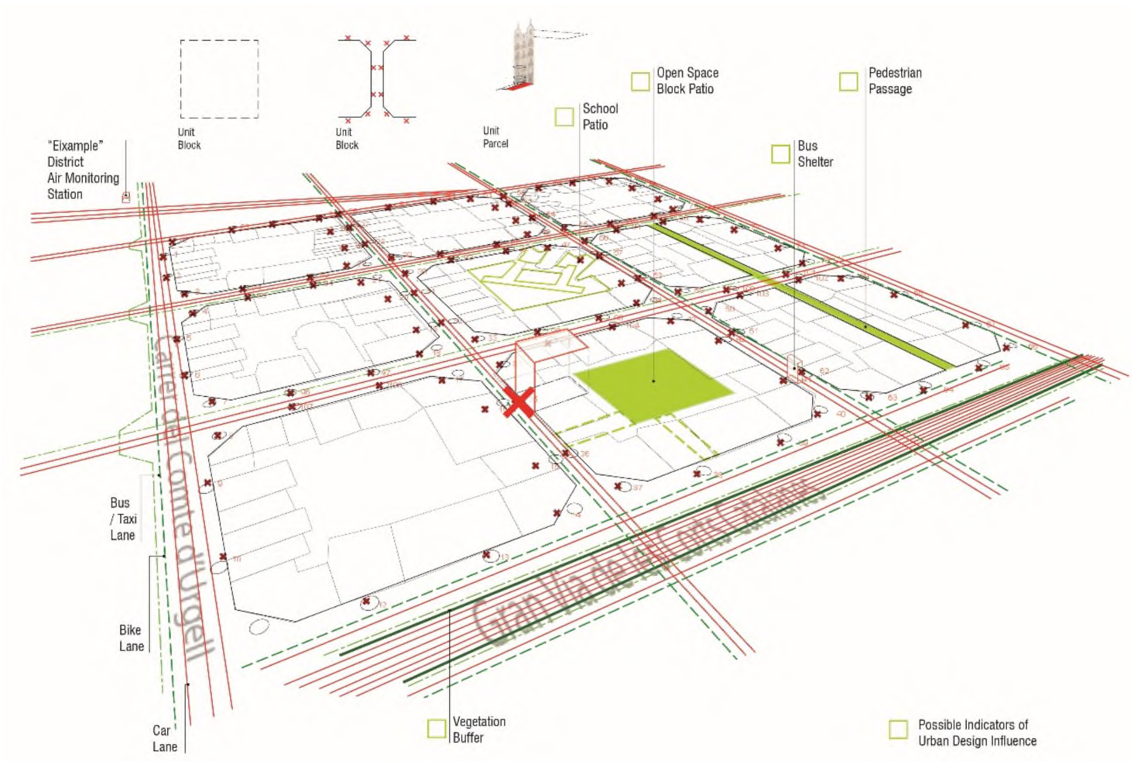

Figure 2 3x3 block study area and 108 data points

The point number, latitude and longitude of the 108 points were uploaded to the Raspberry Pi as a CSV file via the Google Map. Using a GPS module on the handheld device a 'butterfly net' script was written to capture data when the device is walked in the three by three block test area, activated when passed within a 1m radius of each of the 108 points. A protocol was developed for collecting the data both on foot or separately walking a bicycle including speed of movement from point to point and device orientation. The device was enclosed in a 3D printed case to ensure its durability and protection from environmental conditions. The purpose of the prototype device was to collect data for these experiments and was not intended for use by untrained data collection. At least three variations of the prototype device were built.

Figure 3 Data Collection, with device within bus shelter

4 Data: Collection and Analysis

4.1 Barcelona

Collection Test Area in Barcelona

Measurements were taken on March 24, 2014, in the three by three block Test Area 01 in Barcelona's Eixample district between Compte de Urgell and Villaroel, and Arago and Gran Via. Pre-test measurements were taken the prior day. Data was taken at one height holding the device. Future data will include ground level, inhalation level and at 5m above grade. Test observations included spring pollen, the influence of wind and the need for various protocols, control tests and observation recording.

Collection Limits and Future Prototype Criteria

Natural Environment

The sensitivity of the Sharp sensor was calibrated using a Dylos DC1100 Pro [3] and later a battery powered Dylos DC 1700 for onsite control testing and other future control test will use high quality instruments lab of Xavier Querol of the Spanish Research Council, CSIC in Barcelona. The Sharp sensor in the device performed with greater inconsistency including 'jumps' in data recording when compared to data from the Dylos. However data from the Sharp was assessed as adequate to identify significant PM differences between locations. Future in-lab control tests will study the effects of observed wind, pollen, the distance from the sensor to the PM source, sensor orientation and the time of exposure. Careful tracking of the age of the sensors will also be followed. Tests will be taken at high and low traffic times. A wind damper and improved sound sensor will be added. Additional ambient environment sensors such as anemometer wind sensors may be added. While these future tests will help ensure greater accuracy of absolute data findings, it would not affect the purpose of this research to establish an integrated working methodology using robotics and GIS visualization to measure high resolution urban design characteristics.

Figure 4 Data Collection, adjacent private vehicles, taxis, motorcycles

Built Urban Environment

Initial observations were made to identify relationships of air pollution levels with urban characteristics, not to create definite results but to inform future methodological data collection protocols and scales. A greater series of data collection would be required, again, to make causal inferences but some observations would inform current improvements to the initial robotic and GIS methodology of this research work. Test observations of urban design criteria included possible sources of data variation:

- Effects within or around bus shelters
- Ground-level storefront uses (example, car painting shop on Urgell and pizza shop)
- Building height
- Street slope
- Street orientation to sea and mountains
- Distance to criteria such as traffic lanes, pedestrian medians and vegetation buffers (example, Gran Via)
- Zoning use sensitive to children including schools and parks

The Everyday Route

This first phase of the research aimed to discover emergent spatial patterns of air pollution within the city's urban fabric. Thusly an undifferentiated grid of 108 points was used. However, knowing the specific user patterns of young children and the respective path of them and a parent, would provide a useful spatial understanding that begins from the presumed path of the everyday activities of parent and child. Future tests may follow the possible everyday route of a two-year old child across but not limited to Test Area 01and will include interior residence locations, schools, shops, parks and other open spaces. Figure 2 demonstrates the relationship of places both within the 108 point protocol as well as off that grid of points. The geospatial visualization of the point set allowed the work to identify these future tests examining the effects of the built design characteristics in multiple dimensions including plan, section and 3D, allowing a greater resolution of data measurement given the prescribed path. The points along the everyday path would most probably not be evenly distributed at 33m intervals and thusly understanding new scales of data visualization were revealed from this current work. This approach is similar to the Intel study in Portland that presumed air pollution sources, using a presumed spatial parameter to begin the work, but is different in that it does not presume the source of air pollution.

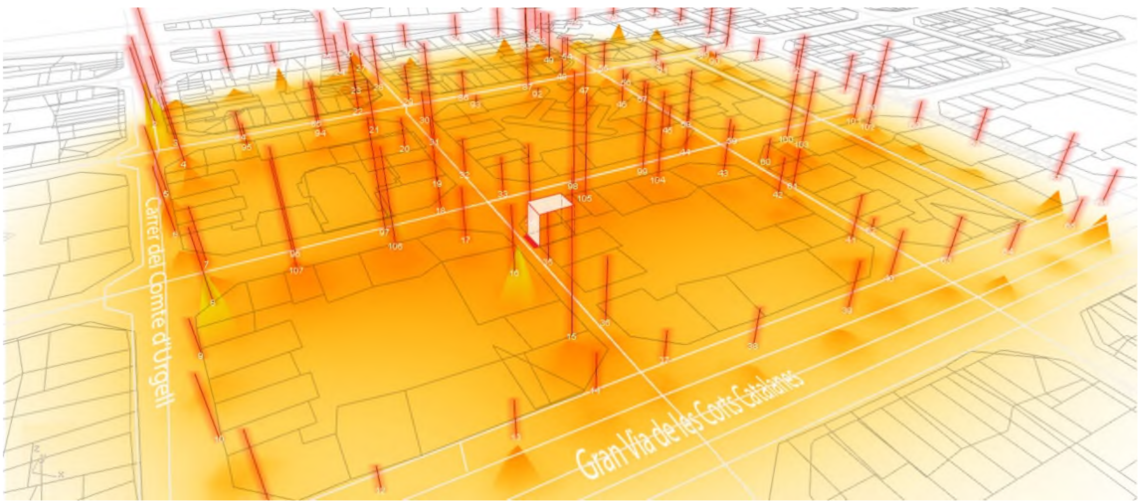

Figure 5 3x3 block study area, PM0.5 data visualization at 108 data points

Analysis / Visualization

Data from the 108 point Test Area 01 was analysed in Rhino Grasshopper and visualized. Future analysis and visualization will integrate degrees of information such as PM, ambient environment (sound, wind) and urban form and quality. An objective of this visualization was the ability to read both integrated data and the individual degrees/layers of information with graphic differences such as z-vector, colour, line weight, line type and transparency. Future diagrams of unit parcel, section and city block will be added as well as diagrams of parametric workflow. The visualization required the custom computation to control colour, height and line thickness ranges with data that did not meet visualization ranges. Rhino Grasshopper provides an effective parametric environment to make mathematical and spatial calibration in an intuitive human computer interface.

Sidewalk and pedestrian

Bike median and vegetation buffer

Figure 6 Gran Via de Les Corts Catalanes

The visualization analysis provided and communicates a relative difference of data between points rather than an absolute understandings of data referenced outside the study. According to the data, particulate matter does not disperse like ozone or CO2. PM levels were significantly different across the test area and future *sueprilla* urban unit. Significant differences could be measured between 33m data points, not to mention between urban blocks. Before discussion of the results it is important to point out the research involved the development of new scales and language of visualizing data. Traditional GIS from municipal shape files would not have the resolution of this data nor the ability to openly choose criteria to measure and the mathematically customizable visual language to do so. Rhino Grasshopper parametric software with geospatial plugin Elk and custom scripting allowed this new scale of data to be visualized and compared with the urban characteristics of street lanes and open courtyard public spaces both from existing OpenStreetMap data and from newly collected data.

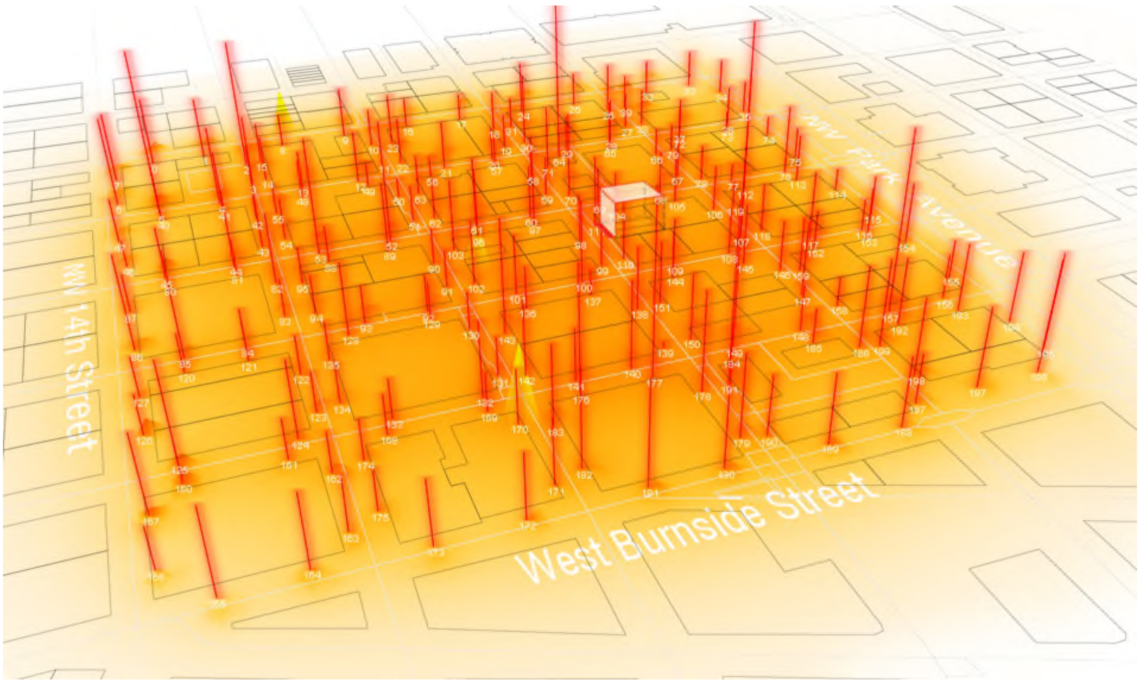

Figure 7 Portland, 3 x 3 block area, PM0.5 data visualization

The result of this research is a preliminary confirmation of the importance of the scaled understanding of suspended particle PM air quality and urban design characteristics at the small scale within an overall regularized block structure. The research focuses on the workflow to understand this particular scales of geospatial data. For example, PM measurements at the sidewalk along the high traffic of Gran Via de Les Corts Catalan were low. This may be a result of broad airflow at this atypically wide street, limited vehicular traffic of two lanes including taxi/bus lanes, adjacent pedestrian and bike lanes and or a low vegetation wall buffering the additional six lanes of vehicle traffic. The accuracy of measuring twelve points around each 100m x 100m *Eixample* block provides this detail, filling a gap in the research of PM air quality in cities that epidemiologists such as Jordi Sunyer are eager to have. The contribution to the research is not the specified results, which certainly would require calibration with absolute metric and multiple measurements over the day, week and year, but to prove that a higher resolution of data collection may provide insight into relationships between atmospheric phenomena such as air pollution and the small, human scale of urban design. The research revealed additional new questions and problems in the workflow mostly related to the translation of data into spatial visualization.

Figure 8 Data Collection in Portland, United States, adjacent street trees, parking, TriMet Streetcar

4.2 Portland

Collection Test Area in Portland

Comparative measurements were taken with the same device in Portland using the Dylos 1700 and a decibel recording device. Tests were done on June 7, 2014, in the five by five block Test Area 01 in Portland's Pearl district between NW 13th Avenue and NW Park Avenue, and NW Glisan and W Burnside Street. Pre-test measurements were taken the prior week in Eugene, Oregon. Data was taken at one height holding the device. For sound measurement a smart phone application called Decibel Ultra [22], external microphone and wind screen were used. Test observations included high measurement readings at restaurant locations especially pizzerias, consistently lower readings at adjacent park and tree locations and the need to periodically reset the Dylos 1700.

Portland testing was done to test the battery powered Dylos 1700 and new sound recording method. Sound was recorded using an iPhone, application, external microphone and wind-screen. Measurements were taken every one hundred feet apart at the centre location of Portland quarter blocks, typically at building entrances. Data was passed from both the Dylos and sound recording device in Portland via a second person entering data into a table spreadsheet on a separate device. The wind screen and improved quality of the external microphone resulted in sound measurements that appeared to be more consistent that data collected in Barcelona without a wind screen. Other tests the following day in Eugene, Oregon suggested very elevated PM levels in Eugene as predicted from Eugene's typically high PM count from pollen and local grass seed operations in the adjacent Willamette Valley in the spring season. While such relative testing within the city and between cities does not prove an absolute accuracy of the device, it does suggest the value of relative data and that differing locations in Oregon approximately one hundred miles apart would show very different PM readings.

Built Urban Environment

The value of this method of research in Portland as in Barcelona was the relative understanding of what relationships may exist between air pollution and urban design. And as the purpose of the work is to slowly approach an effective way to measure PM in high resolution related to urban condition, the absolute values of the data between the two cities was not used to determine observed variations in the research methodology. Test observations in Portland suggested possible urban design influences that would refine future iterations of the data collection and analysis. As some urban design conditions were different in Portland than in Barcelona, a greater application of urban design characteristics could be studied. The work revealed potential areas to focus continued research in greater detail in the future, including:

- Restaurants (ex. pizzerias) and outdoor barbecues
- Adjacent open park space (ex. North Park Blocks)
- Street trees and rain gardens
- Street slope
- Street orientation to westerly prevailing wind locations
- Traffic (ex. Burnside Street)
- Zoning use (ex. residential over commercial in the Pearl district). Future test at industrial zoning us in the Portland East Side 'industrial sanctuary' may be useful

Many of these observations were entered in a general notes column following column entries for PM and sound data. Future tests may measure some of these phenomena and urban characteristics in a more quantifiable method with additional sensors, perhaps resulting in a similar question of everyday path versus evenly distributed grid. Likewise consideration may be made of the everyday activities of children and parents in the Portland Pearl *neighbourhood* test area. Changes in the research method may address the accuracy of the sensor, distances between data points, duration of data collection and comparison with other data. Greater benchmarking studies may allow for more absolute findings of the air pollution data that might provide closer insight of the impact of urban design on health conditions.

5 Limits and Discussion

A more detailed examination of the results and limits of the visualizations made from both Barcelona and Portland data would suggest refinements to the research method. These refinements represent a critical consideration of both the sensor device and the geospatial analysis. An integrated list of these ideas includes:

- Device consistency.
- Measurements of wind velocity and direction, relative humidity and temperature at locations.
- Consideration of geospatial urban scale and data point location differences.
- Time of day and year consideration including seasonal affects such as pollen count.
- Urban design characteristics: building heights, street widths, sidewalks, parking, rain gardens, street trees, and low vegetation and traffic lanes.
- Other user based urban design differences between Barcelona and Portland including: pedestrian behaviours, bikes, bike-share, motorcycle and moped numbers, private vehicles and the impact of transit vehicles such as buses, streetcars, car share and metro use.

Challenges related to the device not only suggest opportunities for calibration improvement with the various sensors but also opportunities to improve the methodology of data collection. Consistency of data collection is inherently challenged when data measurements are taken at differing times allowing variations in environmental conditions such as wind direction and velocity, relative humidity and rain as well as variations in transit use such as peak transit hours. Relative humidity for example has been identified in recent research of similar inexpensive handheld particulate matter sensors to be a consistent source of degradations of the results, especially over 95% humidity [26]. Some limits included the effects of relative humidity on that date showed a spiked value of 93% at midnight and dropped to 37% at 4pm, supporting data from a US EPA study citing top levels of 90%+ relative humidity causing drops in accuracy of handheld PM devices including the Dylos 1700 [26]. The tests in both Barcelona and Portland took two to four hours to collect all the data points. Wind velocity can change in the time. Wind direction and velocity may also change. Rain may affect data measurement as well as humidity. These are only an initial list of concerns related to time and use of the sensor. A recent proposal for a future study for PM measurement of ports in Spain suggested the collaboration with meteorologists a future change in the method that also represents an earlier point about urban ecologies understandings as broad integrations across varying disciplines and knowledge areas in the built urban environment.

Geospatial visual analysis faced other challenges. Geospatial data in the two resulting images presented here for Barcelona and Portland (figures 5 and 7) suggest that 3D urban information may be helpful. The challenge is the effective visual understand of data over a densely populated three dimensional background.

The inclusion of material differences such as vegetation, both street trees and low hedges, may have also offer insight into possible relationships as well as the quantification of that data in degrees of vegetation density and location. There may exist a way to visually record the passage of time in the data, from start to finish, such as a timeline or time stamp next to each floating data point. The reliance on linear walks or bike trips to record data suggest that the geospatial analysis of this data, like the device challenges, may suggest changes to the protocol rather than the objective of this contribution of the research to understand absolute information about air pollution and urban design. The device and geospatial analysis presented here could be used in a city to identify locations of studies with sensor devices of greater precision. But when cities areas are very large when recording this high spatial resolution of data, it may be useful to provide a relatively fast, cheap and less accurate analysis to then focus on more representative study areas and findings about repeated urban design conditions such as street tree species and vegetation canopy, low hedge, bus stop locations and park locations within blocks – all conditions that are systematically repeated at the same scale in cities with even grids such as Barcelona and Portland.

6 Conclusions, Summary and Future Research

6.1 Deployment and Attachment

The mobility of the device allows a more diverse investigation of urban design characteristics that fixed monitoring stations do not afford. Bruno Latour's idea of 'attachment' suggests that we better understand the environment by capturing its meaning dynamically over time [8]. Information technology allows this new understanding of the built environment. Complex methodologies to collect data, analyse it and visualize it are enhanced using parametric workflows to identify and codify data into understandable information. The interdisciplinary interaction of computer science and urban design expertise is strengthened through iterative methodology design. An isolated research method across these two field would not have resulted in the integrated process experienced in this research. Proposals for future tests are strengthened through interdisciplinary design teams. Future data may be collected with unmanned aerial vehicles or drones currently in discussion with the mayor's office of Barcelona and via public infrastructure such as city buses, street cleaners or police vehicles. The data collection completed on foot and on bicycles in the research presented here provides a valuable control test for protocols of these other data collection methods until legal and regulatory frameworks are established, for example in the case of UAV's. The relatively low sensitivity of the Sharp sensor ($25) was deemed acceptable with high jumps in data measurements. Data sensitivity may be enhanced using a combination of more costly Dylos 1700 portable sensors ($400) tuned with high-end devices ($10-20,000) from the Spanish Research Council. This work is begun but not completed at the time of this writing.

Thusly an important summary of the research work is the scale of resolution. How cans a design methodology that moves back and forth between scales of PM resolution provided reliable results and thusly inform urban design recommendations? Traditional urban design methods drawing such as plan drawing uses this very approach moving between scales often moving from the large scale of regions and cities down to the small scale of districts, neighbourhoods and blocks. New understandings of urban ecology today breaks this methodology from large scale to small scale, often beginning with careful investigation of unit variations at the small scale. Today the parameterization of data allows for analysis both from large top down organizational approach and small scale bottom up unit characteristics. As small relationships such as the type of leaf canopy of a tree, the street width of a large avenue or the type of lanes of traffic may all affect a much larger urban design approach. The ability to iteratively move between data findings and the visualization of small parameter variables, to use higher and lower resolution in varying scales of data collection, all are valuable to understand the complexities of urban ecology today. In fact the results discussed here may even suggest a dynamic or parametric resolution expressed in real-time data visualization. Perhaps streets of time-based variations of urban conditions trigger a smaller spacing between data points, a reiteration of data measurement across the day (related to traffic for example) or a return path or gridded area using a more sensitive device. And perhaps the feedback to both researchers and the general public would be of greater resolution of accuracy and time when site conditions changes such as peak traffic use and high relative humidity.

6.2 Urban Design

The relatively fine scale of PM air pollution measurement may require even smaller scaled measurements of typical urban design conditions such as block structure, open space, street width, pedestrian buffers and vegetation than currently exist. The way we see and measure urban design may change. Future tests including the everyday path of a two-year old child will provide additional information about known sensitive location such as homes, kindergartens, parks, benches along sidewalks and pedestrian streets with proven connections of indoor and outdoor air quality [25]. Additional neighbourhoods and different urban morphology may be tested. The aim of this information is not only to inform city planners and government agencies but more importantly to empower everyday citizens, namely parents of children, with improved decision making for the healthy growth of our next generation. How people receive this information may reveal similar challenges to the research done here such as what is the effective resolution of information based on the purpose of the investigation. The visualization variables tested here, namely colour, line height and line width may be accompanied by a greater description of information such as floating text, icons and qualitative images. The ability for the information to vary with different user groups may parallel similar analysis questions revealed to the researchers in the work done here.

The implications also suggest that the discipline of urban design is changing. The way urban designers collect and understand data as temporal phenomena is different than previous traditional understandings largely based on fixed characteristics such as road widths and land use types. Traditional urban design methods such as fixed maps or master plans from high above the earth's surface does not provided guidance for how we design an interconnected ecological understanding of the urban environment that serves its inhabitants in a given time. The idea of resiliency with a dynamic environment and adaptive urbanism may require a fundamental different mechanism to support the change of people's values over time. Perhaps like the IaaC Cisco study, sensor may more and more be given to citizens without a specific user group in mind such as children. A greater feedback loop, perhaps automated for this research, would provide an agency [5] that responds to local and timely needs of data and enhance the scalability and the ability to repeat data gathering more frequently and more accurately.

The idea that civic entities, such as cities governments, are responsible and capable of meeting the need for knowledge of grossly differing values of user groups with in a city, seems ineffective. New health concerns and standards, and the differing concerns among community members, suggest adaptive tools to measure the urban environment. One city or neighbourhood may have a different belief in the effectiveness of air pollution for example and require a different resolution of geospatial information. We are only recently learning of the impact of air pollution on the health of the general population, not to mention the effect on unborn and young children. Inexpensive devices and open geospatial tool sets allow each society and the smallest scale interest group, to capture their own data, analyse their own information and to create their own knowledge. The design professionals and city planners increasingly rely on making their own design tools that engage human and non -human interface to create an urban ecology that creates the attachment of people and place that Bruno Latour describes in today's dynamic and interconnected world.

Bibliography

[1] **AirData**, Interactive Map, US EPA, PM2.5 criteria selection [www.epa.gov/airdata/ad_maps.html]

[2] **ArcGIS** (1999) Environmental Systems Research Institute

[3] **Dylos** DC1100-Pro Sensor, particle sensor, DC 1700-Pro rechargeable [www.dylosproducts.com/ornodcproair.html]

[4] **Franck K** and **Lepori R** (2007) Architecture from the Inside Out: From the Body, the Senses, the Site and the Community. Routledge London

[5] **Gerber D Shiordia R Veetil S** and **Mahesh A** (2014) Design Agency: Prototyping Multi-Agent System Simulation for Design Search and Exploration, Proceedings of the Symposium on Simulation for Architecture and Urban Design

[6] **Heumann A** (2011). Human (Formerly Heumann Design/Tech), Plugin to Rhinoceros 3D by Robert McNeel & Associates

[7] **IaaC** / **Cisco** (2014) Citizen Sensor, citi-sense.nilu.no [www.iaac.net/events/citizen-sensors-fablab-barcelona-iaac-launches-a-new-crowdfunding-campaign-for-smart-citizens-269]

[8] **Latour B** and **Yaneva A** (2008) Give Me a Gun and I Will Make All Buildings Move: An Ant's View of Architecture. In Geiser R ed, Explorations in Architecture: Teaching, Design, Research. Birkhäuser Basel, 80

[9] **Logan T** (2012) ELK plugin for Grasshopper

[10] **Lynch K** (1960) The Images of the City. MIT Press Cambridge

[11] **Nabian N Offenhuber D Vanky A** and **Ratti C** (2013) Data dimension: accessing urban data and making it accessible, Proceedings of the Institution of Civil Engineers Urban Design and Planning 166 DP1, 60–75

[12] **Speranza P** (2013) Green Design, Materials and Manufacturing Processes, Parametric Places 22@: Smart Urban Analysis Tools and Place Branding Value. In Helena Bartolo et al eds, SIM Conference Proceedings, Taylor & Francis London, 701-705

[13] **Mostafavi M** (2010) Ecological urbanism, Lars Müller Publishers

[14] **Norberg-Schulz C** (1976) The Phenomenon of Place. Architectural Association Quarterly 8:4 3-10

[15] **Pederson M** et al (2013) Ambient air pollution and low birth weight: a European cohort study (ESCAPE), The Lancet Respiratory Medicine, 1:9 695-704 [www.thelancet.com/journals/lanres/article/PIIS2213-2600%2813%2970192-9/abstract]

[16] **Pope C Ezzati M** and **Dockery D** (2009) Fine-Particulate Air Pollution and Life Expectancy in the United States. The New England Journal of Medicine 360 [www.uphe.org/wp-content/uploads/2011/12/nejm-improved-life-expectancy-and-air-quality.pdf]

[17] **Rueda S** et al (2012) Guia Metodológica Para los Sistemas de Auditoría Certificación o Acreditación de la Calidad y Sostenibilidad del Medio Ambiente Urban

[18] Centro de Publicaciones Secretaría General Técnica Ministerio de Fomento, Madrid, Spain

[19] **Rueda S** (2014) Superilles. Agencia de Ecologia Urbano de Barcelona [www.sostenibilitatbcn.cat/index.php/superilles]

[20] **Rutten R** (2007) Grasshopper & Galapagos. Robert McNeel & Associates Seattle.

[21] **Schaefer P** (2013) Decibel Ultra [itunes.apple.com/us/app/decibel-ultra/id410139517?mt=8]

[22] Sharp Optical Sensor (0.35mg min; 0.1mg/m3). GP2Y1010AU0F

[23] **Speranza P** (2013) Green Design, Materials and Manufacturing Processes, Parametric Places 22@: Smart Urban Analysis Tools and Place Branding Value. In Helena Bartolo et al eds, SIM Conference Proceedings, Taylor & Francis London, 701-705

[24] **Sunyer J** (2014) Interviews with Jordi Sunyer conducted between January and March of 2014 at the CREAL Biomedical Center Passeo Maritimo, Barcelona

[25] **Vitiello R** and **Willcocks M** (2006) The Difference is in the Detail. Place Branding 2:3 248-262

[26] Williams R, Kaufman A Hanley T and Garvey S(2014) Evaluation of Field-deployed Low Cost PM Sensors, Office of Research and Development, National Exposure Research Laboratory, US EPA/600/R-14/464 [www.epa.gov/ord]

[27] **WHO** (World Health Organization - Organització Mundial de la Salud) DP1 60–75 [dx.doi.org/10.1680/udap.12.00011]

[28] **Woodbury R** (2010) Elements of Parametric Design, Routledge

[29] **Wong K** (2013) Intel squeezes into smart (and crowded) sustainable cities space, GreenBiz.Com [www.greenbiz.com/news/2013/06/28/intel-squeezes-crowded-and-smart-sustainable-cities-space]

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[2] **Blackman, D A** (2001) Does a Learning Organisation Facilitate Knowledge Acquisition and Transfer? Electronic Journal of Radical Organization Theory, 7:2 [www.mngt.waikato.ac.nz/Research/ejrot/Vol7_1/Vol7_1articles/blackman.asp]

[3] **Buxton, W** (1997) Living in Augmented Reality: Ubiquitous Media and Reflective Environments. In: Finne K, Sellen A and Wilber S eds, Video Mediated Communication, Erlbaum, Hillsdale N.J., 363-384

[4] **Dixon, N M** (2000) Common Knowledge: How companies thrive by sharing what they know, Harvard Business School Press, Boston, MA

[5] **Djenidi H**, **Ramdane-Cherif A**, **Tadj C** and **Levy N** (2004). Generic Pipelined Multi-Agents Architecture for Multimedia Multimodal Software Environment, Journal of Object Technology, 3:8, 147-169

[6] **Gorard, S** and **Selwynn, N** (1999) Switching on to the learning society? Questioning the role of technology in widening participation in lifelong learning, Journal of Education Policy, 14:5, 523-534

[7] **World Bank** (2002) Social assessment as a method for social analysis, World Bank Group [www.worldbank.org/gender/resources/assessment/samethod.htm]

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