**VO Selected Topics in Geoinformatics-20231113\_083041-Meeting Recording**

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Yeah. And with that, I think we are

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set and what it to go, uh, welcome Chad Long. We had met quite a few weeks ago when Chad was, I think it was for about a month right, spending time in Salzburg.

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So the Scientist in Residence programme sponsored by the City of Salzburg and the topical connection was with the Suitcase Mobility Group. So I if I remember correctly, you had been working with Martin Lydall and his team during that period of time

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gave Electro as well. So here we want to make that accessible to, yeah, a different audience, which is the audience mostly of mobility and international students at the department.

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I have to acknowledge and be very, very grateful for Chad, uh, to do that on his part of the world in a rather unusual time frame.

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Uh, you can see this, UH, with the University of Western Ontario. Is it Western University now? OK, yeah, they they just wanted to rebrand. But it's still technically still Western Ontario. That's the UW O and the URL. That's still valid. OK, that's how I recognise this university,

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which is quite a few hours off. So it's very, very early morning for you and again we are grateful for you to offer that talk at this time of the night on your end. And again as you can already see from the title,

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we do have a focus again on on mobility, analysing mobility. And I'm particularly like the using spatial graphs in here because graph analytics somewhat related to to link analysis, which is one of the really emerging topics in spatial analytical methodology. So there's a lot we can do with that with increasing levels of abstraction of spatial connection,

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spatial mobility, movements and all of this. So we're looking forward, not taking any more time away from you. Get the screen. Is yours over to you?

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OK, thanks very much. So, yes, um, I was visiting uh, the beautiful city of Salzburg, UH, earlier in the year in September.

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Umm. And I had a very nice time meeting some of the PhD students in the department of Geoinformatics and meeting with some of the faculty members and scientists around the department. And I'm going to talk to you about some work that I've been doing recently. So this is relatively new things that I've been working on about looking at individual mobility using spatial graphs. And so I'll kind of walk you through why I think this is a useful

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idea and how we can kind of go about doing it with GPS tracking data.

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Let's see if I can.

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OK. There we go. So for those of you that don't know where the University of Western Ontario is or where rebranded Western University is, it's in London ON Canada. So we're a different London than the one over in England, much smaller. And we're actually situated right in what's called the Great Lakes basin, which is kind of in inside of all the Great Lakes. And actually, from where I live in London, it's very easy to get up to Lake Huron or down to Lake Erie,

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and they're both beautiful places to go to the beach. Um, and there's lots of kind of nice things to do around the Great Lakes. You can see we're also halfway in between Toronto and Detroit. So if we want to go to a big city, we typically go to Toronto or Detroit,

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um. And so my research focuses on what we like to call now the integrated science of movement. So we've written some papers on this. And basically, the idea behind the integrated science of movement is that there's lots of people studying individual movement of various forms, whether it be transportation geographers, UH, social physics, human geographers, classical GIS analysis. But then a whole bunch of people

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that study different types of animal movement, um, and all sorts of other UH applications. And the part of UH movement analysis I'm most interested in is the analysis of GPS tracking data. So I'm going to talk a little bit about specifically some of the data sets that I'm working on where we've tracked people and animals with GPS devices.

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And the way I like to frame this is that we work very computationally on movement analysis. So we often call this computational movement analysis analysis, where we have large data sets on many individuals that we've tracked with GPS, whether they be

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animals or humans in a variety of applications. And I'm very much interested in computational methods for studying the spatial and temporal patterns in these data sets. So you can imagine these data sets are typically fairly large and the patterns are often fairly complex. So we often try and use computational methods to understand those patterns.

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And in terms of the areas that I work on, I I work in the area of human mobility and I'm going to talk a lot about one study where we've tracked a bunch of people using GPS and I have a couple of sort of thematic areas in the area of human mobility that I work on. So the one I focus mostly on is this idea of outdoor recreation and recreation, ecology and parks and natural areas. So I've done a lot of work where we've tracked people in GPS

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in specific hiking areas or trying to understand human impacts on animals. Um,

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but also worked quite a bit on home based working and mobility. And this is uh, a GPS tracking data set that I'm going to talk about today where we tracked a bunch of people with the specific interest in focusing on people that work from home. And this was actually before the COVID-19 pandemic and we started to look at this kind of question of home based working and changes in mobility related to the COVID-19 pandemic as well. And so I've done this in two using two different kinds of ways,

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technologies for tracking people. So the first was uh, a mobile phone application that we developed or or got a company to develop with our kind of guidance and we kind of surveyed people and got them to install this app on their phone. So we had about 800 participants in that study in Canada. I'm also working with a major cell phone company where we have what's called network mobility data, which is essentially cell tower connections. So it's not as good as GPS tracking data

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in terms of the spatial resolution, but we have a much larger sample. So it's very, very powerful for studying kind of national level patterns.

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And the other area that I do a lot of work on is animal GPS tracking, which is the field of movement ecology. So I work with biologists and collaboration on a variety of different studies where we're interested in understanding animal movement and performing spatial analysis on GPS tracking data on animals. And a couple of things that I'm kind of focused on are sort of home range analysis methods, but also this idea of spatial temporal

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interaction. So when we track more than one animal at the same time in the same study area, we can study how they interact with one another. And so those kinds of questions are really interesting to me. But in general, I think my background in GIS has allowed me to be kind of focused on interesting methods for leveraging kind of spatial analysis methods to study animal movement.

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And one of the more interesting studies I'm working on right now is what we call the Long Point Coyote Study. So Long Point is just a what's called a National Wildlife area in Canada, it's a sandspit that goes 40 kilometres out into Lake Erie. So it's right on the Great Lakes and it's just a really cool place in Southern Ontario to do field work. And we've got some GPS collars on coyotes and we've been doing camera traps and other field

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work in this kind of really unique ecosystem, which in this part of Canada is quite wild because most of southern Ontario is quite human dominated.

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OK. So

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that's kind of where I'm coming from. And today I'm going to tell you a little bit about a a method or a tool that I'm actively developing that I think is really useful for studying spatial patterns of individual movement. And I use the word term individual movement here specifically because spatial networks are used extensively to study aggregate patterns of movement. So when we're talking about flows between regions or if we're looking at aggregate

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patterns of travel, um or migration or or other kinds of UM goods being traversed between regions. So we use spatial graphs all the time, spatial networks all the time to study aggregate movement patterns, but we haven't really used them a lot to study individual movement. So this is an area of of interest for me.

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So why did I want to do this? This goes back to my masters.

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Um and this is a bit of a story. So when I was doing my masters I studied not movement, I studied forest fragmentation. Um and specifically I was looking mostly in the province of British Columbia which is on the West Coast of Canada. And there was a really influential paper on forest land cover patterns by some Americans. The first authors last name was Ritters. It was published in 1995 and this paper did a factor analysis of landscape pattern indicators.

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So basically, um, landscape pattern indices are just metrics that we can compute on categorical maps to give us a measure of different dimensions of pattern. And if you don't know what factor analysis is, factor analysis allows us to essentially look at a whole bunch of different characteristics or variables and then try and come up with sort of unique dimensions that are associated or correlated

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amongst those variables. And so they did a factor analysis of over 101 hundred landscape pattern indices and found out that there was only about 6 unique dimensions of spatial pattern in these categorical land cover maps. So we can quantify all sorts of things, but only about 6 unique dimensions exist and everything else is kind of correlated with those dimensions. So that that was a very important paper when I was doing my Masters that really stuck with me.

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And then as I started working in movement, I started to realise the same pattern creeping up in that there's lots of ways we can quantify movement, but there's not necessarily a good discussion of how these different measures are correlated. That wasn't till about 2019 when there was this really nice paper out of out of the group in Zurich. So this is one of Rob, Rob Weibel students actually and she wrote this really nice

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paper where she took the spatial dimensions of human mobility. So they there was only about 16 in this case and they determined that there was only about 6 unique dimensions of human mobility and these are what they found. So extent is kind of how far you move, quantity is, how many activities you have time spent in. Active travel is just kind of a measure of of duration, of movement, stability of life. Space is kind of the same as the stability of your activity

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space or how similar your spatial pattern is over time. Then elongation was simply a measure of essentially how elongated or skinny or movement spaces. And then timing of mobility is not a spatial dimension but it is about the timing of activities. So those are the dimensions of mobility and what you realise is when you start to analyse GPS tracking data. So this is GPS tracking data from the UK that we collected is that the

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the patterns kind of become really complex when you look at lots and lots of different people and the spatial patterns are very complex.

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So one of the questions I was grappling with was, were these 6 dimensions that were outlined in this nice paper by Felicias from from the Zurich group,

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Were they capturing all the things that we were seeing in our data? Were we missing things? And one of the reasons I thought we might be missing things is that a lot of those dimensions that we capture with these regular movement indices are pretty simple. So one of the most common things we do is we calculate the convex hull, which is just the the convex Polygon, which is kind of like the outline or the boundary of all the points. And that's one of the dimensions and that's pretty simplistic for what are generally

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very complex patterns.

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So then I got to thinking is if there are other dimensions, can we of movement, can we quantify them using spatial networks or spatial graphs? And so that kind of set me down this path of calculating and developing this idea of spatial graphs for individual movement. And in the 1st paper that I wrote about this idea, I called them activity graphs. But I'm kind of rebranding that just like my university is rebranding. So I'm going to call it move graphs

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going forward. So I'm going to talk about move graphs in this UM presentation and I'm going to also use the UH phrase activity graphs, but I'm referring to the same idea, so movement as a spatial graph. So I'm going to try and explain what I mean by that. So we know that spatial networks are widely used when we study human mobility and transportation. So I was talking about regional flows. We also use spatial networks all the time, every day.

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Most of us use them for routing. So anytime you query Google Maps to get from point A to point B, you're using spatial networks. And believe it or not, but spatial networks are widely used in movement and spatial ecology as well. When we think about like classical lease cost path problems, these are used to quantify what we call landscape connectivity.

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So these kinds of tools are being used in all sorts of areas that are very close to studying movement.

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So if you don't know what I mean by spatial network, um, I'm sure most people do, but for if they're just in case there's anyone that doesn't. And network is essentially a structure that's defined by two fundamental elements, nodes, which are point locations in this case, and edges or links, which are connections between those nodes. And so if we the probably the easiest way for us to think of

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spatial network is to think of a road network where nodes are intersection and links are essentially streets or roads connecting those intersections.

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But we're going to think about as a spatial network in a slightly more abstract uh way when we talk about a move graph. So not necessarily just intersections and roads.

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And with any kind of network we can estimate costs associated with those network elements or weights. And so in the classical case the the edges have a travel time or travel distance and the nodes might have a stop time or other rules about how you can go through those nodes. So this is how we routing network would be used. And of course, these networks can also be directed or undirected. So an undirected network has the same

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cost in both directions, whereas the directed network might have different links that only go in certain directions and the cost might depend on the direction as well.

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So we can factor all these things into networks, and that's why they're really useful in geography and they're really useful for spatial analysis.

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Umm. And they are a way to constrain or simplify space. So in a routing network, you can't move outside of the network, Your route has to go through that network. Umm. And we could think of them as an abstraction of two-dimensional space. Why? It's often called a 1.5 dimensional space. So it's a simpler version of space than two-dimensional space. And it's this simplification of space or this abstraction of space that makes them really

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interest to interesting to me as someone who studies complex patterns and movement data.

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So I propose that we could use spatial graphs or move graphs. We might call them as a simple tool to analyse spatial patterns in individual movement. And if you think of an individual's movement, an individual's movement pattern, we can decompose it or deconstruct it into two fundamental things, umm, stops or activities,

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um, which? Which are going to be the nodes of our graph, and trips or movement, which are going to become the edges of our graph. And we can associate weights with these things. And we can have directed graphs then that demonstrate an individual's movement, and we can have weighted graphs that then incorporate some sort of weighting function associated with that movement.

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And this very simple representation of an individual's movement I propose is going to be useful for studying their spatial patterns.

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So this project, um, was prior to COVID-19 and it was focused on understanding new ways of working and basically focused on people that work from home or have a small business from their home. So those are the home working or self-employed. And the Pi on this project was an economic geographer whose expertise is in home based working, and she wanted to work with me because I had expertise in GPS tracking and mobility analysis.

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So we developed an app, or we actually had a company develop an app for us. And this is my my child with a snowman on my phone showing how the app works. But basically we did three things. We had a comprehensive survey when people downloaded the app that kind of got baseline information about them, like their income and their education level and stuff like that. And then within the app we sent them trigger or questionnaires. Trigger questionnaires,

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which is called geographic ecological momentary assessment, associated with times during the day or whenever they finished the trip. So the app would sense when they finished a trip and would trigger one of these questionnaires. And we get information about, like where they were, who they were with and how they felt. And we also kind of had a feedback reward system to encourage people to participate. And they had to get so many days of participation to get the kind of final reward from participating in. Yeah,

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but the part I'm interested in was of course that this app allowed us to track people with GPS at a relatively high resolution while they're moving. And the app had a little sort of geofence trigger that turned the app off or the GPS part of the app off when they were stopped. And like I said before, this in app questionnaire was triggered at the end of every trip, so at at every stop and also at some other intervals during the day. And most people

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do not answer very many questions, but they because they're getting asked a relatively high number of questions, even if they don't answer every question, we still got actually quite a lot of questions back at associated with these trips. And so I'm not going to talk about these questionnaire triggers, but my PhD student Milad gave a nice presentation about this at the recent GI Science meeting about how people's happiness was associated with

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different characteristics of their trips.

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Umm, so this

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project it in in the end we had about over 1000 people. Um,

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participate. But as you can see only about 800 provided us with what we're calling relatively good data. And the number of people that have good GPS data varies with your kind of

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thresholds, you might say, for defining what a good data set is. But for the purpose of this, we'll say there's about 800 people with good data, but in total, there's over 3 million GPS points. Over 200,000 of these emo A questions were triggered and about 25,000 of them were answered, actually more, Yeah, sorry, over 263,000 in total and about 20, four, 4000 or 28,000. Sorry, we're answered

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in total. So we have lots of data on people's movement in the UK and we focused on 2 cities, UH, or three cities in particular.

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So like I said before, this GPS tracking data provides us with really complex, uh, information about people's movement behaviour. And so we need ways to kind of analyse it and then associate it back with the things that we're interested in. So we want to be able to say, you know, how do people's movement patterns differ if you're a home based worker versus not a home based worker. That's kind of fundamentally what we're going after.

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So when you collect GPS tracking data, you get you know a whole bunch of points like this and then you need to kind of come up with a way to turn that into usable data to analyse. So typically what we did is we focused on cleaning it. So looking at you know the GPS signal, repeat coordinator, repeat coordinates and we had this zigzag pattern happen in in a few cases where it looked like someone was going back and forth, back and forth as they were moving,

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which of course they weren't. So we had to do some cleaning of GPS points. But then in order to build these so-called movement graphs we had to derive stops or activities. So we use the spatial clustering kind of algorithm based on a threshold of about 75 metres and at times threshold of 5 minutes. So basically if you were in a small area of 75 metre radius for greater than 5 minutes, we identified that as a stop and then GPS data connecting stops

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are essentially those trips or moves.

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So that kind of processing algorithm takes a bit of work that's kind of the more computational part of this to identify these stops and moves that we can then use to build these movement graphs.

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So to build these activity graphs we clustered these stops. So because a person often goes to the same place multiple times, we want to identify that stop as the same node in the graph. So we actually then use like a a spatial hierarchical clustering to group those stop locations into a single node in the graph. So for example, if I go to work multiple times

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like every day for a week, then I want my work to be the same node in my graph. So then we have those clustering of those stop locations into these unique nodes because of the fact that most people go to the same place multiple times.

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And then we build the graph from the stops and the moves and the moves between the stops into the spatial movement graph. And in this case we weighted the the the graph, the links in the graph based on the trip distance or travel time. And so we can do different things and get different metrics depending on what we want to do, but in this case it was distance. But I've I'm playing around with travel time and other options as well.

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And so we had 800 people in the analysis that I'm going to present here. And each person has a a map that looks kind of like this one on the right. I think this is actually my wife'll movement graph because I'm not actually allowed to show you anyone that was in the study. I'm not supposed to show show like an individual's GPS track. So this is actually my wife when we lived in Scotland and you can see that this is the variety of her stops that have been clustered into stops and moves.

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The moves aren't shown here.

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So once we get a graph, one of the things I was interested in, well, what can we quantify about these graphs? So I focused on 14 graph measures that are quite commonly used in sort of network analysis or graph analysis, and I focus on what I call global measures. So basically, our data was approximately 7 days for each person. Some people were more, some people were less, but we calculated these metrics based on the entire

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graph that we had. So it wasn't based on a single a lot of these metrics you can calculate for each node and things like that. We focused here on basically getting one number for each individual for each metric or each measure, and these were all computed with the igraph package in R And so the question that I was really interested in is this bullet point on the left where I say, can we relate these to individual movement patterns?

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So basically

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each one of these graph measures, um, has kind of a definition in terms of what it means in terms of the graph, but can we relate these to movement patterns? And if so, what does that tell us? And if not, what else are we missing?

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And so I calculated all these graph measures, but then I also calculated each one of these 6 dimensions of mobility that were identified in that Felicias paper in 2019. So we have these different measures that we're trying to calculate like extent, quantity, duration, stability, elongation and timing. So we calculated all those as well for each person in our data set.

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And we're actually going to ignore this timing one because I was really interested in spatial dimensions of mobility and all of the graph indices that I chose are related to spatial things of the graph. So I have nothing about time really in any of my analysis here. And we're going to see that kind of come out later. But right from the beginning, I just ignored this timing thing. We're not going to worry about time kind of measures of mobility quite yet.

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So and then I did a factor analysis just like that. So this is where the kind of things are starting to come full circle. So I actually found 4 dimensions based on the

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14 graph measures that we chose. So we chose these 14 graph measures of movement graphs. And we found these 14 graph measures result in 4 dimensions of mobility. So what were those 4 dimensions? Well, they were actually connectedness, which we'll talk about quantity, which is the same as before extent, which is also the same as before in clustering. So I'm going to talk about each one of these

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4 dimensions. So connectedness was associated most with the degree centrality graph based measure and it's essentially a measure of how interconnected all the nodes in the graph R. So you can think of some people may have lots of nodes in their graph and they may only have a couple connections to each one. So they kind of infrequently travel between all the different nodes in their graph. Whereas other people might have the same number of

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nodes or activities in their graph and they're very well connected in. And. What that means is they go from each one of their note stops or activities to any one of the other nodes at some point in time in their graph.

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So this idea of being highly connected or or not

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in our movement patterns, quantity was the same as before. So this is literally the number of stops or the number of activities in your graph. Extent is also the same as before, although in this case it was the average or Max distance in the graph, but it's directly related to those other kinds of extent measures that we typically measure.

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And finally, clustering, and this is a very interesting one for me because clustering, umm, the associativity measure or the alpha centrality measure, they're kind of measures of the importance of singular nodes. So how how important is a single node or or subsets of nodes within the graph? And so graphs where there are nodes that are particularly important or well connected in the graph have higher values

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in this clustering dimension. And so this is kind of interesting because we might think that you know for example home based workers might have higher clustering values because they're more focused, they're their home is more central or important within their overall movement pattern. So we'll see how that plays out. So we did some other things as well. So we looked at the relationship or the correlation between all these factors

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and we can see that the extent um is easily quantified by graphs. The quantity and duration also captured here, but are correlated and that graphs are movement graphs did not capture elongation, which I was a bit disappointed about, or stability. So I think there's work there or there's things that we could do with graphs to try and also capture those known dimensions and mobility.

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Ohh

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and so for example this this arrow is pointed to the strong correlation between the Max distance and the extent. So this is one of the dimensions that was quite easily captured by graphs. We then have another arrow pointing to quantity or the size of the graph. Is it perfectly correlated, correlated with quantity. So this is 1. We're obviously doing very good on. So this is just the number of stops or activities. And then graphs did not capture

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elongation or stability, so there were no strong correlations in the bottom here. So this is an area where I think we could do some work with graphs to capture these known dimensions of mobility.

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So I I kind of lied. So these are actual movement graphs of people in our study. So this pertains persons down in Brighton where the dimensions are particularly high, but I've actually kind of faked these a little bit, so the anchors are actually slightly moved. I've added random noise to all these graphs to avoid individual identification. So these are kind of fake versions of real people's graphs. So we can see in we'll focus mostly on the

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A&D here. So in A, we have a person whose graph is highly connected. So it is a high degree centrality and we can see this manifest in this kind of interconnected movement graph. And this one we have this high associativity or high clustering, which means there are individual nodes that are really really important for the sort of structure of this graph.

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And this is just a large graph, so big extent. And this graph up here in B just has a lot of nodes. So these are new dimensions of spatial pattern from individual mobility that are being captured by spatial graphs that were not being captured by any of the traditional metrics that we would normally calculate.

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So that's kind of neat and useful.

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And so one of the pieces of analysis we did was based on where people choose to live. So I choose the current location of my work or residence to minimise my commute. So we asked people that question before they started our survey and what we find is that people that said yes to this tended to have

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higher degree centrality than people who did not do that. And so that's very interesting in terms of, you know what that means for your movement pattern. And similarly there looked to be slight differences between men and women in our study on this as well.

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With this associativity or this clustering uh dimension, the patterns were not so strong. But we did see a difference in men and women in one who did not necessarily choose their current location to minimise commute where there's no difference in those who did agree in terms of the men and women. So this is the kind of analysis that we often do when we have collect mobility data is we compute some metrics and then we compare it across different socioeconomic,

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UH variables. So this is the kind of analysis that we're trying to support with these new dimensions of mobility.

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So basically what did we find? There's two new spatial dimensions of mobility related to the connectedness of people's activities or stops and the clustering around key nodes. And we did not quantify some of the existing dimensions, but we did quantify some. But we can probably hopefully fix or come up with graph measures to capture these two I think. And that will lead to kind of a more holistic use of movement graphs to study individual movement.

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And in the paper we relate this back to Haggen's Hager strands classic space-time cube. So the idea that we can model movement in this space-time cube as a series of anchors and movement connecting those anchors, and hopefully, and I think we've shown this, leads to new inferences about human behaviour and mobility patterns.

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And so if you're interested, you can read some of these papers about this data set. In particular, this paper outlines this idea of movement graphs.

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So but what about animal movement? I talked a lot about this GPS tracking study where we had an app and we tracked people. Can we apply the same framework to animal tracking data to kind of move forward with this idea of the integrated science of movement? So the first question we have to answer is, do animals make stops and trips or moves? And the answer is, well, kind of yes, maybe,

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but it probably depends on the species. And so then if an animal species is the kind of animal that makes stops and trips or stops and moves, how do we identify those or extract those from the data? And so we actually have some tools that are quite popular in movement ecology that allow us to do that. So the one I'm going to use here is called the Hidden Markov Model.

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So I work with a biologist in Texas. His name is Stephen Webb and he does a lot of GPS tracking of different animals. And this data set, our 29 wild pigs, you might call them wild boar over in Austria that were tracked via GPS.

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So in this case we have one point or one GPS point every 30 minutes and these animals were tracked in the autumn or early winter in 2016 and 17. And our research questions are largely around social structure, space use and habitat analysis. And we're gonna I'm gonna propose movement graphs as a tool that can maybe help us with some of these problems going forward.

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So how does this work? We start with raw GPS tracking data. This is case a single pig. And you can see this pig doesn't move very far. It's a relatively small area around a river in Texas,

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um, and we can use that Hidden Markov Model tool that I talked about to identify stops and

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sort of separate those out from the movement activity. So the red dots here are stops that the algorithm has identified within this data set. And you could see that a lot of these stops are clustered and many of them are probably at the same patch. So the animal would go to this patch, maybe move around, then come back to the patch, then maybe move around over to this patch, and then come back and forth and you can see it crossed the river a few times. So some patches are on each side of the river.

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And so we can build that same kind of movement graph that we built with the human mobility data, with this animal movement data, after we've separated out the stops and the moves. And you can see the reason I like this is because it abstracts this really complicated spaghetti map. And I'll come back to this idea of a spaghetti map. It simplifies this into a really nice clean representation of that animal's movement path that focuses on where the stops are located.

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So if we have a a a question that revolves around sort of these high intensity of use stop areas and often habitat habitat analysis does, then this tool might be very useful. And we could see the while the animal went out into this pasture field a lot, none of the stops occurred there. So it's core activity was away from this movement from this field. Sorry.

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And so again, we're going to look at some of the things we often calculate on animal movement and compare it with some of the other tools that were or the other metrics that we identified in our human mobility study. And we can see we might be getting some new spatial information here, although much of this seems to be highly correlated. So this is kind of in progress work. I don't have any solid answers quite yet, but hopefully there's

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a path forward for using this tool to identify new sort of spatial patterns of animal movement. And one of the things I'm most interested in I think is looking at methods for doing graph similarity over time. So there's two uses I think for this. The 1st is to look at the stability of animal movement graphs over time, to look at changes in space use over time, and the other is to compare the activity graphs or movement

42:27  
graphs of individuals to look at spatial temporal overlap between individuals. And there's lots of reasons or lots of questions that we have about animal movement that relate to change over time and habitat or space use and individual

42:45  
overlap in space and time.

42:48  
Um,

42:50  
another thing I'm interested in is can we come up with other graph based indices or modifications of these to allow us to capture all those different dimensions of movement? And then as I kind of alluded to, I think graphs as an abstraction of GPS tracking data are really useful as a tool for visualisation going beyond spaghetti maps. So going beyond these kind of really clustered maps into something that simplifies that

43:21  
complex GPS data into something a little more easy to visualise.

43:27  
Umm. And so in doing so I'm kind of working on building an R package that hopefully does a lot of this. So works with building these move graph objects and has kind of sub objects that store different things that we might want to extract out of those. Has some visualisation tools and then also the processing and analytical tools

43:51  
um so that's I do a lot of my work in our some of you might have other uh preferences in terms of your analysis but that's what I like to do. So just to kind of quickly close up my research looks at the what I call the integrated science of movement. I'm interested in both human and animal movement studies, and often I'm interested in things where we do both, for example, looking at recreation ecology and the impacts of human,

44:21  
um, activity on animals. And I'm really interested in computational methods for studying GPS tracking data, and so hopefully you found it a little bit interesting. At least I do. That maybe spatial graphs, which are this really powerful tool that we use in all sorts of areas of geography, could also be a really useful tool for studying individual movement patterns. So thanks very much, hopefully you get up into the hills. This is a mountain on the West Coast of Canada

44:54  
on Vancouver Island that we hiked up one weekend, and I was smart enough to bring my GPS device to write my name on the top of the mountain. So have some fun the next time you're out hiking in the Alps.

45:11  
That looks a bit like Strathcona Parker somewhere somewhere around there, right? Yeah, so it is, uh, Strathcona in Vancouver Island. Yeah, so this is Mount Albert Edwards. So if you Google Mount Albert Edward, that's this one looks familiar to me.

45:30  
So thanks a lot and America that with an eye on on today's audience that you were introducing not just the instrument of graph and link analysis, but just showing that analysing movement as one part of spatial relations offers a lot of insights into as you say human behaviour, animals and whatever else moves they want there. So

46:01  
any questions again they are welcome in the chat or just raise your hand or we are few enough if you just unmute yourself and speak up.

46:14  
Tanya.

46:16  
So hello, thank you for the presentation, a really nice interesting topic. Thank you. I have a question regarding active citizen participation like how you found your people who answered or yeah, how you advertised your

46:33  
application. Basically, yeah, great question. So, so the I would say that was not my UH

46:40  
job um so this project was well funded. So we had actually we paid a company to recruit participants and we also had we had money to give. So when I say people were rewarded, I mean they were given like a gift card for participating in the project. So I think in our case we are quite lucky because we had a company recruit participants for us and they had rules they had to get because we were so interested in this idea of home based working and

47:12  
home based self-employed or whatever. They had like these quotas that they had to the company had to meet in terms of participants, um other folks randomly,

47:24  
randomly essentially mail out to people. So we had uh, a PhD student work on a project in Scotland where she, I think she mailed like like 5 to 8000 all sorts of letters to random addresses and then if people emailed her back then she got them to join.

47:45  
Sometimes it's more like a two step process where you get them engaged and then once you get them engaged you try and get them to download the app or get a GPS tracker or whatever. But yeah, there there's like it's so slow because you need to get the ethics then you need to get people do this whole mail out thing and then also yeah then get them on boarded onto your system. So it's it's a slow process. So we have, like that's why us having 800 people is a really big data set

48:17  
for GPS tracking. Yeah. So basically it's easier if you pay the people or it's all, it's always easier if you pay someone else to do it. Yeah. Thank you. Thank you,

48:28  
Ohh. It's fine. The sponsor

48:32  
in a further question. So again, you can write them in your hand. Just speak up.

48:40  
Ohh, I have a question.

48:43  
So I was just interested to know like, so the duration of the study, they did have like a start and an end. And after the end, is it that people then have to delete the app or is it something that you're kind of, you know, seeing a future in it and just getting more participants as you go? And I don't know,

49:06  
yeah, great question. So technically, yes, it had to start and end. So because our project was being

49:14  
uh we paid to have people recruited um basically as people joined that we kind of had like chunks. So we had like I mentioned in the presentation, we had two phases. So we did two cities in phase one and then we did a third city in phase two. And they had different numbers for different reasons. But basically people once they got their seven, seven or eight days of data, they were allowed to delete the app and and they were kind of given an e-mail saying thanks for participating, you can now

49:46  
delete the app. What's interesting is there are some people just didn't delete the app and they just kind of left it going, which meant that we were getting some passive GPS data. But some people were like actively still answering the questions for like a month. So there were some people that gave us like a month worth of data when they only needed to give us seven days worth of data.

50:12  
But yeah, so that was kind of neat. Um, but we, we really only used the first seven days of data for any person. The other thing that's tricky with these things is that so our app even within like our study, which was over like a year and a half between the two phases, was kind of rapidly coming up with issues related to Android or Apple. So maintaining an app over time is really difficult

50:42  
and so like we are just a project, so you need to have like an active continuous project with funding and and kind of developer time to maintain an app up to Apple and Android standards over time. That's very difficult in my opinion,

51:01  
No. It's good to learn about this kind of experience, right? So again, welcome for any further questions,

51:09  
there was actually two or three going through my mind when I was listening. Ohh I would

51:15  
argue that kind of two types of trajectories uh those where you know about the network beforehand so that movement along transportation networks. So in a way you then kind of have to snap the defecto GPS projectory to those and never you're walking in in the wild or animal movement you might have to do something like 2 piaster they trajectories

51:46  
and you had it using a different term, you had a slight reference to that uh, you have to cast the project ways to come up with a graph representation were pretty much all the animals move along pretty much the same along the river longer valley, but not on exactly the same or not on the defined track. And that means that the graph only can be established after collecting the empirical data.

52:16  
Do you make, did you make that distinction from a practical, uh, data management perspective?

52:25  
Yeah, good question. So not really. I mean, the processing steps for animal movement data and human movement data are in my opinion, quite different, in part because the resolution of the human mobility data is much higher. So there's actually more cleaning. And like you say, I didn't. I don't think we actually snapped it to the network here in this, in this analysis. I don't think I did.

52:54  
My PhD student probably did when he does it, but I don't think I bothered with that here. I literally just

53:00  
identify the stops and then calculate simple metrics between those stops, like how far the travel was based on the GPS points. But that's a in, you know, if you think about it, a GPS track is an incorrect representation of how far you travel between two points because it has a bit of noise and you're better off snapping it to the grid and saying OK, if they went this way, they went on this road and this is the length of that road. So I I didn't go through that

53:30  
process here but we've done that in other analysis and it's it's roughly the same but it's it's not perfect and it but it's interesting you say that about animal movement because they actually do

53:43  
follow networks sometimes where they're they have paths and they have there are routes that are repeatable and and defined but not always. Yeah it depends on UH topography and talent cover I guess. Yeah whether they apply to to go on a well trodden path in one or another way. Yeah. And maybe sort of related to that, but everyone, I'm still looking, but everyone watches voices to hands related to that.

54:15  
You mentioned that the UM

54:19  
sequence or the temporal granularity of acquisition like with the wild balls was relatively low. So that's I guess a power management issue on the on the tracking device.

54:34  
And then you have the distinction you kind of said like there's not maybe not really the same kind of stops like for human behaviour. Well yeah, but on the other hand there will be stops for for sleeping and feeding and some other behaviour. And the the course of the temporal resolution is the harder those would be to identify. And maybe with animals it's not district distinction whether you are a destination where you spent some time and then you move to the next destination.

55:03  
It's maybe more ambling, welcoming. Uh, did you look into anything like a guardian of space over time? Which would be velocity or speed in a way

55:17  
to not make the strict distinction stop or go,

55:22  
but rather to spend time in an area where you don't really move at a brisk pace or just being in a transition to another place. Of course that again is impacted by what you say the noise of GPS and the temporal resolution of the sampling you would have,

55:44  
yeah, that's a good question. There's there's probably lots of ways to think about that. So yeah, the algorithm that we used is essentially we, we said, OK, give us, give us the two two things, give us the fast and it's essentially fast and slow movement.

56:03  
And then we say it's OK if it's slow. And I kind of like tweak the thresholds to try and make the slow movement closer to stops. But you could say, OK, give me 3, give me 3 categories, give me slow, medium and fast. And then what do you do with that medium? Maybe you can think about it the, the way I've been thinking about is actually kind of reversing it. What if we know where the patches are on the landscape? And then we say, OK, these are the patches.

56:30  
When you're there, are you stalked or are you moving and kind of trying to reverse engineer the graph based on the landscape, which will work better for some animals than for others, But um, from a theoretical like sort of a spatial ecology theoretical perspective. That I think would be an interesting strategy as well.

56:53  
The same maybe would apply this considering the landscape as such would apply for going for home range for anything like a convex hull. Of course, it's a purely geometrical

57:06  
first approximation, which has a nice property of being projection invariant, right? OK. I don't see any further question there. So

57:18  
thanks a lot. I think that's great learning opportunity about kind of data and analytics which for many in our field are not kind of our everyday activity and against very special appreciation to join us at a very uncomfortable inconvenient time of the day for you. So thanks a lot. Hope you get some good rest for the rest of the night and hope to to be in touch and see you again one way or another. Thank you.

57:48  
Well, thanks very much and good luck everyone on your masters courses is I think that's what most of you are here for. So yes, take care.

57:58  
Thank you and goodbye.

58:00  
Bye.