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Characterising Farms by the Movement of Animals through Them

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ABSTRACT

We describe a pilot study that arose from a workshop of domain and visualisation experts, and present preliminary work in which we begin to visually characterise holdings (farms) by the movement of cattle through them. This ongoing study suggests that this is a useful approach for helping DEFRA understand risk of disease spread.

Index Terms: Human-centered computing—Visualization—Visualization application domains—Geographic visualization; Human-centered computing—Visualization—Visualization design and evaluation methods

1 INTRODUCTION

The Animal and Plant Health Agency (APHA) is the UK Government agency responsible for monitoring plant and animal diseases and taking appropriate action to help reduce the impacts on agriculture, the environment and the general public.

Cattle is an important sector of UK agriculture. For the last twenty years, individual cattle movements between ‘holdings’ (farms and agriculture-related sites including abattoirs, markets and shows) have been captured, forming the “Cattle Tracing System (CTS)” database (as in many other EU countries). The data are used in various operational settings, e.g. helping designing surveillance protocols, where the movements of animals need to be identified to help control the spread of diseases when they are found. However, these data have not really been used beyond these operational uses than respond to particular incidents.

The movement of animals and humans is the most important factor affecting disease or pest outbreak. For APHA epidemiologists and other modellers, knowledge and understanding of the movement of animals is key to the decisions and interventions that happen in response. Identifying holdings at risk involve understanding the sources, destinations and timings of animal movement between them. Interventions may include forbidding animal movements to and from certain areas within certain timescales, or even forbidding movement altogether. Although relatively easy to investigate for specific incidents (because there are more constraints on what to consider), a more general understanding of how cattle are moved around is more difficult as movement behaviour can change by season and over time. For non-expert senior decision-makers, an understanding of how policy decisions are informed by the analysis is important. For organisations representing the needs of farmers, advice and policy need to be justified in terms of the science.

To assist, we are *characterising holdings by the movement of cattle through them, by designing metrics that capture aspects of movement that might have implications for disease spread*. Through visual summaries in an interactive visualisation interface, we are helping establish the effectiveness of these metrics for characterising holdings. This work is helping APHA better understand the significance of their operations in terms of surveillance.

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2 PILOT STUDY

We investigate how we might usefully characterise the movement of cattle in and out of holdings, eventually using these as bases to cluster holdings. There are obvious simple cases where this may relate to function – animals do not leave abattoirs alive; agricultural show animals travel from a permanent base to different shows and then back to their permanent base; markets take animals from a wide geographical range and redistribute them – but there may be more subtle examples. These clusters may also relate to risk of disease spread – holdings whose animals regularly move in and out within a short space of time may have a higher risk of unwittingly spreading disease further, especially if sources from high-risk areas and move to geographically diverse destinations. Our work takes inspiration from existing work that infers the semantics of places by temporal characteristics of the visit of people (e.g. [1]). Our pilot study is structured thus:

- Talk to APHA staff as to what are important issues and why.
- Calculate different measures at a holding level, including those that characterise temporal and geographical differences in movement. Get APHA feedback on these.
- Visually summarise these measures.
- Facilitate geographical and temporal filtering to explore the stability of these measures.
- Experiment with clustering holdings based on these features.

3 INITIAL RESULTS

With 185 million individual movements, we selected geographically- and temporally-constrained subset of animals that passed through Gloucestershire in 2010, reducing the set to 400,000, whilst retaining the complete movement history of every animal in our set. Zooming and panning the map serves as a geographical filter in Fig. 1) for the holdings and their “movement signatures”, listed on the right and sorted by the number of movements, with the red/blue portion of the bar indicating in/out movement (some of the holdings have in- but not out-movement). The mouse pointer is over an abattoir with only in-movement, identified by a green dot on the map. The is too cluttered to interpret, but serves as the (geographical) selection mechanism for “movement signatures” in the right. These capture aspects of the movement of cattle through the holdings. The orange histograms show (from left to right) **frequency distributions** of all cattle movements for each holding:

- **By year.** Although the observed patterns are generally expected – given the temporal filtering – some holdings appear to take older cattle than others.
- **By month of year:** A bimodal spring/autumn distribution can be observed. The question is does this apply to all holdings?
- **By duration spent before moving on:** As expected, the majority of holdings move cattle on within half a year (the left-most bin). However, some keep cattle on the premises much longer. APHA are particularly interested in those identified as regularly moving cattle on within a short time. We can begin to characterise and quantify how this could help inform risk-based interventions.

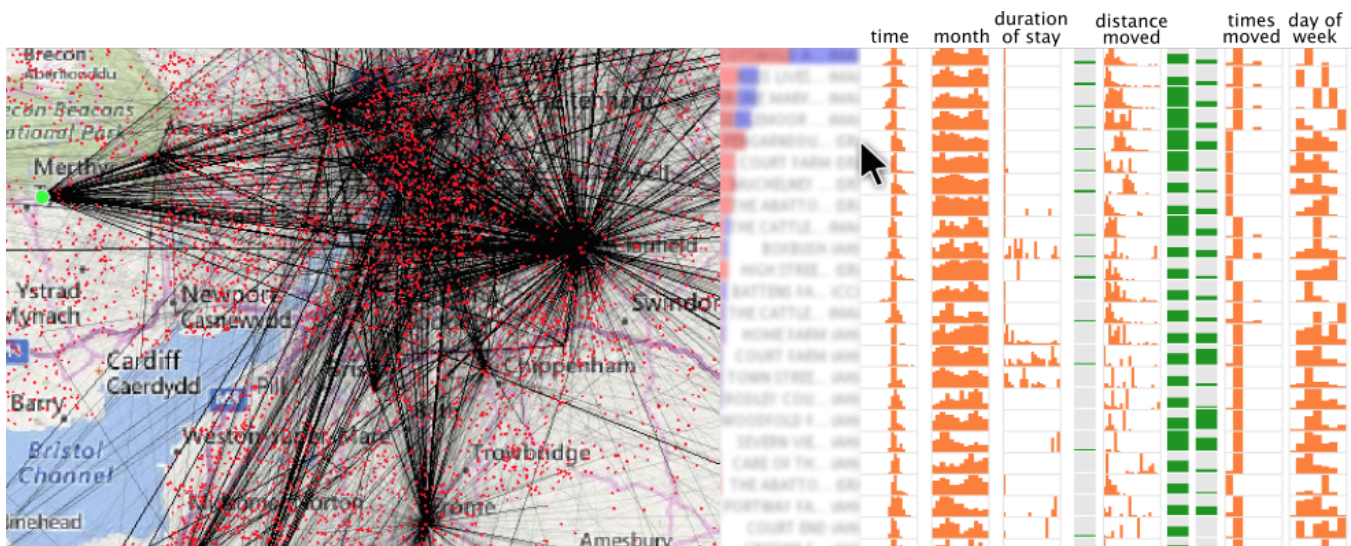


Figure 1: Red dots indicate holdings. Black lines are the movements of cattle between them (see Fig. 2 for clearer representation). **Movement signatures** for each holding are on the right, where each row is a farm (names blurred) within the map view, sorted by the number of cattle movements. Orange histograms show (from left to right) **frequency distributions** of cattle movements and the green charts show **proportions** as indicated in section 3. *Data source: DEFRA.*

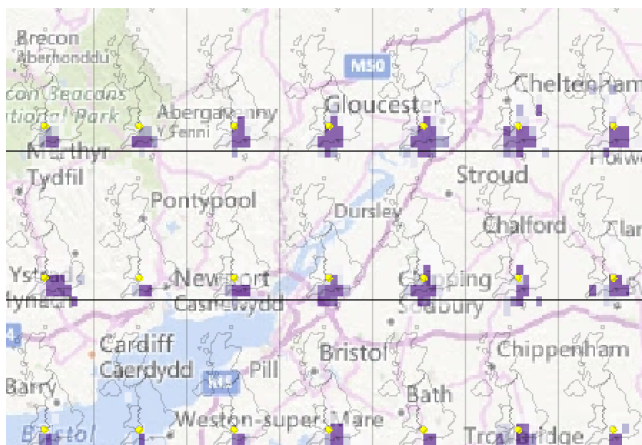


Figure 2: DO map (OD map [2] with origin and destination reversed) is a better representation than in Fig. 1 (left). Indicates geographical *origins* of animals in the UK maps for the *destinations* indicated by the rectangles. Destinations tend to have animals that originate south of them (yellow dots).

- **By distance moved out:** Holdings whose animals come from or to distant locations may represent a greater risk in terms of contributing to longer-range spread of disease, though the riskiness of the area may be more important.
- **By frequency moved by individuals:** holdings that receive animals that regularly move may be at higher risk of disease as they are exposed to more places.
- **By day of week:** This indicates routine behaviours that correspond to markets, abattoirs, etc. whose activities are on particular days of the week.

The green charts show **proportions** of:

- **Unique holdings:** This tells us whether the cattle come from a small or large pool of holdings; the latter of might be of concern.

- **Unique animals:** This tells us the extent animals revisit the holding. Some holdings receive the same animal multiple times, for example bullocks being hired out or animals entering shows.
- **Dairy vs beef cattle:** Indicates the particular type of holding.

The characteristics of the movement of cattle through holdings can also inform other risk-based approaches including welfare concerns and general compliance with other responsibilities, particularly with regards to “traceability” requirements.

Fig. 2 is a DO maps (OD map [2] with origin and destination reversed), showing that source of the animals tends to be from south of the destination – but not in all cases – and with different sizes of geographical spread.

4 REFLECTION AND FURTHER WORK

This preliminary work so far shown that these movement signatures are a good basis with which to explore movement characteristics of holdings with APHA. It is helping establish the characteristics that may help APHA usefully characterise holdings. The characteristics we are investigating are based on conversations with APHA and we plan other workshop to consider these and others. Once we’ve established a good working set of characterisations, we will be experimenting with clustering holdings based on these and considering changes in movement characterisation over time. We are working closely with APHA to develop effective visualisation techniques and characterisations of movement.

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