Towards a Spatial Decision Support System for Animal Traceability

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This section presents the contributions of our work to the problems of bovine traceability and contact between animals using trajectory database concepts. This section describes how to delimitate problems and how to represent animal movements as trajectories. Afterwards, the algorithms for the identification of contacts between animals are presented for the calculation of contamination probabilities.

In this work we define contamination algorithms for foot-and-mouth disease (FMD). FMD is a highly contagious disease that attacks all cleft-hoofed animals, mainly bovines. It occurs at all ages, regardless of sex, breed, climate, etc. The virus spreads by direct contact of animals as well as through the air, water and food.

The virus is present in high concentrations in the liquid of vesicles of the mucous membranes of the tongue and in the soft tissues around the hooves. There are high concentrations of virus in the blood during the initial phases of the disease, during which there are serious infection risks to other animals. Sometimes infection can be indirect, the virus is carried through the food, water, air and birds. Likewise, people taking care of the sick animals carry the virus on their hands, clothes or footwear, therefore contaminating healthy animals. The incubation period varies from eighteen hours to three weeks.

In this work we consider two parameters for the calculation of contacts within the trajectory concept, which are set for FMD but that are common to other diseases as well. The first one is the number of days necessary to guarantee that no contamination has occurred: 90 days. This period determines a time interval where contacts must be calculated for later verification. The second factor is the area within the premises that must be interdicted. Initially, it is possible to use theses values to determine the size of an activity area (buffer) and subsequent contact between animals. Finally, we make a realistic assumption on the geographic location of animal movements, which allows to improve the performance of contact computation as it reduces the number of trajectories considered by our algorithm. Indeed, we consider scenarios wherein farms use extensive and semi-extensive production systems. This means that animals can move between paddocks under the control of farmers.

The movement of animals between farms or from farms to slaughterhouses, which is done through roads, can be deduced and studied by analysing the existing road structure, however, this is not the subject matter of our work. We are interested in bovine movements into farms and, more specifically, into paddocks.

The data generator produces points representing animal positions inside the paddocks. For each point, geographical coordinates and time data (day and time) are collected. Thus, the following step is to transform these points into information representing the movements of the animals in a format that allows advancing towards more intelligent operations. For this purpose, we consider that movement between two points is carried out in a straight-line. Based on this assumption, we have proposed a model of trajectories. In order to represent the trajectory of animals, we provide the definitions of point, segment, trajectory and journey.

Definition

- ***point***: *a point is a geo-localised acquisition represented by the geographical position and its associated time (day and time).*
- ***segment***: *a segment is a line connecting two consecutive points in a ordered list of points throughout time.*
- ***trajectory***: *a trajectory is a sequential set of segments, in accordance with the semantics defined by the decision-maker.*
- ***journey***: *set of trajectories.*

The semantics determining the beginning and end of a trajectory depend on what is being observed. For example, in our case study, beginning and end may be associated with the entry of the animal in the farm and its exit. Another example can correspond to the first and last day of protection against disease associated to some vaccination. An example is shown in Figure 10.

Three classes have been created: Journey, Trajectory and Segment. Segment is the simplest class and it represents collected points. Trajectory is an aggregation of segments, and Journey is an aggregation of trajectories.

Two important variables for the algorithms of contact between animals and calculation of the contamination percentage have been considered: Activity area and IBC.

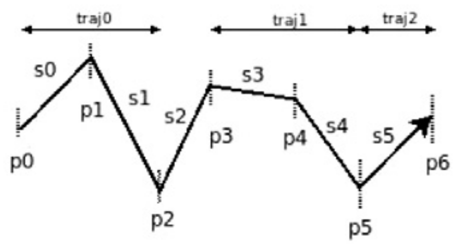

Figure 10: Segments and trajectories

Definition

- **Activity area**: is the buffer zone around a trajectory where there is a probability of contamination (see figure 12). Buffer represents a zone around the trajectory with an identical distance for each one of the sides;
- **Interval between contacts (IBC)**: is a time range that represents the number of days during which there is contamination risk (see Figure 12).

FMD belongs to a group of diseases that are transmitted from a distance from the contaminated animal. Distance from the trajectory may vary depending on the wind, relief or rains. In our work we consider a distance of 3 km.

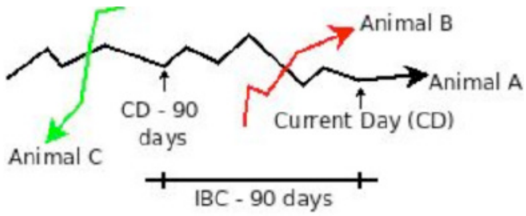

Figure 11: Trajectories and IBC

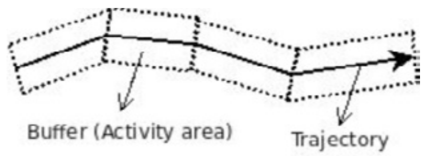

Figure 12: Trajectory and buffer (activity area)

Finally, when considering the transmission of a disease as FMD, it is not only necessary to verify the intersection or crossing of trajectories, but also to try to delimit an area around the trajectory (buffer), and to verify the intersection of these areas with animal trajectories. Thus, before formalizing contamination contact taking into account IBC and Activity Area let us introduce Temporal Contact, Spatial Contact and Spatial-Temporal Contact.

Definition

- ***Temporal contact***: *If trajA is the trajectory of animal A and IBCtrajA is the subtrajectory of trajA having IBC boundaries as starting and ending times. Being trajB the trajectory of animal B. Temporal contact exists when there is a temporary intersection between IBCtrajA and trajB.*
- ***Spatial contact***: *If trajA is the trajectory of animal A and ACTtrajA is the Activity Area of trajA. Being trajB the trajectory of animal B. Spatial contact exists when there is a topological intersection between ACTtrajA and trajB.*
- **Spatial-temporal contact:** If trajA is the trajectory of animal A and is trajB is the trajectory of animal B. Spatial-temporal contact occurs when there are temporal contact and spatial contact.

Two algorithms have been developed to calculate spatial-temporal contacts between animals according to the time units used to define segments: day and hour.

The two techniques proposed have been tested on simulated data to find contaminated animals that have been in contact, according to three kinds of contacts defined.

As a conclusion, the traceability information system presented herein has proved to have the potential to increase product quality and trustworthiness as it improves the precision of the traceability process. The proposal focuses on an important target that involves a large number of actors around a relevant subject in what regards human health. This information system should be useful for government institutions and farmers in case of a relapse, saving time, costs and contributing to achieve food safety.

For further information:

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