Using Data-Stream and Complex-Event Processing to Identify Activities of Bats

Extended Abstract

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1 Background and Motivation

Traditional tracking of bats uses telemetry [ADMW09]. This is very laborious for the biologists: At least two of them must run through the forest to get a good triangulation. And, only one bat at a time can be tracked with this method.

The Collaborative Research Center 1508 of the German Science Foundation (DFG) has been established to develop more sophisticated sensor nodes for the bats to carry[1]. These *mobile nodes* must not be heavier than the telemetry senders used so far, but they offer much more processing capacity in addition to sending a beacon with an ID.

Ground nodes receive the signals transmitted by the mobile nodes. They are also sensor nodes that run on batteries. Currently, all their detections are forwarded to a central *base station*, where a localization method integrates them into a position estimation for each bat [NKD+15]. The base station is a standard computer with sufficient power and energy. In the future, some parts of the localization may already be done on the ground nodes to reduce the data transmission and thus save some energy.

Output of the localization method is a *position stream*. Each element of this stream contains a timestamp, a bat ID, and x and y coordinates. While the biologists would like to have a z coordinate as well, it cannot be provided at the moment because of technological restrictions. Plans are to include it in the future. While filtering and smoothing have already been done, the precision of the coordinate values depends on the localization method used. It may only be in the order of meters to tens of meters, or (with much more effort) in the range of decimeters. Furthermore, some positions may be missing in the stream. A bat may be temporarily out of the range of the ground nodes, or its mobile node may be switched off to save energy. Hence, the subsequent processing must be robust with respect to imprecise position values.

[1] The sensor nodes are glued at the neck of the bats. After two to four weeks, they fall off.

2 Goals and Challenges

The goal of this work is to investigate the use of of data-stream processing (DSP) and complex-event processing (CEP) to extract information meaningful for biologists from the position stream described. Biologists are interested in patterns of bat behavior, which are known to some extent, but have not been observed over longer periods of time, and have not been correlated in time for a group of bats. The elementary parts of the patterns can be expressed in terms of flight trajectories, which are a special case of semantic trajectories [PSR+13]. Biologists however are more interested in bat activities indicated by sequences of trajectories.

Our idea is to identify these activities with the near-real-time processing that a combination of DSP and CEP can provide. This gives information on current activities earlier to the biologists, so they could go out and check by themselves what is happening. Also, they can experiment with the bats by providing extra food or emitting sounds. Furthermore, the mobile nodes on the bats can be configured to some extent, as can be the ground nodes. So when a particular behavior is reported to the biologists, they can adjust the localization method, e. g. switch to higher precision, even if that costs more energy.

In order to reach that goal, a first set of DSP queries and CEP rules has been defined. Activities are managed as objects for each bat. A change of activity is triggered by events and is recorded as an update of this object. Current activities as well as the previous activities of each bat are displayed for the biologists. Ongoing work evaluates the activity detection by comparing the output with the known activities of bats in a simulation tool. It has already helped to adjust the substantial number of parameter values used in the DSP queries and CEP rules.

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