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Shape Database Classification using Advanced Machine Vision Methods and Stationary Transformed Features

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Abstract

The goal of this research is to model an "activity" performed by a group of moving and interacting objects and use these models for shape detection, tracking and segmentation, finally detecting the shapes. Previous approaches to modeling group activity include co-occurrence statistics and Dynamic Bayesian Networks, neither of which is applicable when the number of interacting objects is large. We treat the objects as point objects and propose to model their changing configuration as a moving and deforming "shape" using ideas from Kendall's shape theory for discrete landmarks. A continuous state stationary transformed feature is defined for landmark shape dynamics in an "activity". The configuration of landmarks at a given time forms the observation vector and the corresponding shape and scaled Euclidean motion parameters form the hidden state vector. The simulated results show that the presented method is superior to traditional techniques.

Keywords: Shape Detection, Average Recall, LDA, Retrieval, Transform

INTRODUCTION

The dynamical model for shape is a linear transform based method model on shape "velocity". The "shape velocity at a point on the shape manifold is defined in the tangent space to the manifold at that point. Particle filters are used to track the stationary transformed features, i.e. estimate the hidden state given observations. Shape is defined as a change in the shape activity model, which could be slow or drastic and whose parameters are unknown [1-3]. Drastic changes can be easily detected using the increase in tracking error or the negative log of the likelihood of current observation given past. But slow changes usually get missed. We have proposed a statistic for slow change shape detection called database classification and shown analytically and experimentally the complementary behavior of database classification and for slow and drastic changes [4-5]. We have established the stability of the errors in approximating the database classification for changed observations using a particle filter that is optimal for the unchanged system. Asymptotic stability is shown under stronger assumptions. Finally, it is shown that the upper bound on database classification error is an increasing function of the "rate of change" with increasing derivatives of all orders, and its implications are discussed Another contribution of the thesis is a linear subspace algorithm for pattern classification, which we call Principal Components' Null Space Analysis [6-8]. We have derived classification error probability expressions for professional methods and compared its performance with that of subspace linear discriminate analysis both analytically and experimentally [4]. Applications to shape detection, human action retrieval, object/face recognition are discussed. Co-occurrence statistics involves learning individual and joint histograms of the objects. Joint histograms for modeling interactions is feasible only when the number of interacting objects is small. Stochastic shape dynamics on the other hand implicitly models interactions and independent motion of a group of objects of any size i.e. it is scalable in the number of interacting objects. DBNs define high level relations between different events and typically use heuristics for event shape detection. Our algorithms can be used to provide a more principled strategy for event shape detection. Another advantage of our framework is that using shape and its dynamics makes the representation invariant to translation, in-plane rotation. The idea of using "shape" to model activities performed by groups of moving objects is similar to recent work in literature on controlling formations of groups of robots using shape.

MATERIAL AND METHODS

For modeling the dynamics of the changing configuration of landmarks in shape. The observed configuration of landmarks at a given time forms the observation vector and the corresponding shape and motion parameters form the hidden state vector. The stationary transformed feature is nonlinear and hence we use a particle filter [4] to track the state. Shape is defined as a change in the shape dynamics, which could be slow or drastic and whose parameters are unknown. The problem of shape detection motivated our research on slow and drastic change shape detection in continuous state stationary transformed features. we propose statistics for slow and drastic change shape detection in continuous state stationary transformed features and study the effect of approximation errors in estimating the statistics using a particle filter optimal for the unchanged system. We also discuss extensions to activity segmentation and tracking. In the last, we discuss Principal Component Null Space

Analysis which is a pattern classification algorithm, evaluate its classification error probability and compare its performance with LDA. We present applications of this algorithm to shape detection, action retrieval and to face and object recognition. The shapes of database are shown in Fig. 1. The problem of shape detection explained above motivated our research on slow and drastic change shape detection in continuous state stationary transformed features when change parameters are unknown. Drastic changes can be detected easily using the increase in tracking error or the negative log of observation likelihood. But slow changes usually get missed. We use a particle filter to estimate the posterior probability distribution of the state at time. we propose here a statistic called database classification which is able to detect slow changes. database classification is the conditional expectation of the negative log-likelihood of the state. now, the average recall is optimal for the unchanged system and hence when estimating for the changed system, there is modeling error. Also the particle filtering error is much larger. But using stability results from [5], we are able to show that the approximation errors are eventually monotonically decreasing with time for large enough number of particles.

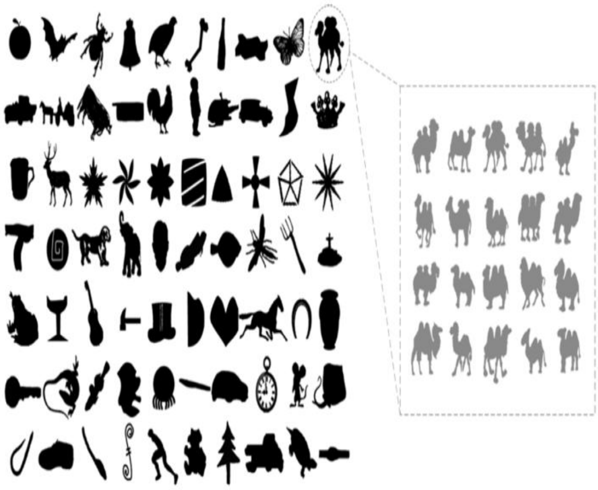

Figure 1 some random image from database

RESULTS AND DISCUSSION

The best of our knowledge, database classification defined as the expectation of log likelihood of state given past observations, in the context of stationary transforms has not been used before. Database classification detects a slow change before the average recall loses track. This is useful in any target(s) tracking problem where the target(s)' dynamics might change over time. if one can detect the change, one can learn its parameters on the changed system model. We have used database classification to detect changes in landmark shape dynamical models and this has applications in shape detection, medical image processing and activity segmentation. Other applications of database classification are in neural signal processing and medical signal processing. Database classification can also potentially be used for network congestion shape detection since congestion quite often starts as a slow change. we develop models for the configuration dynamics of a group of moving landmarks in shape space. The shape of a group of discrete points is defined as all the geometric information that remains when location, scale and rotational effects are filtered out. The original vector of landmark locations is known as the "configuration" vector. In this paper, we extend the static approaches to defining dynamical models for landmark shape. Also, we use these models for the dynamics of shape formed by a group of objects. For a dataset of similar shapes, the shape variability can be modeled in the tangent hyper plane to the shape space at the mean. The tangent hyper plane is a literalized version of the shape space literalized at a particular point known as the pole of tangent projection. Typically one uses the Procreates mean of the dataset as the pole. The tangent plane is a vector space and hence techniques from linear multivariate statistics can be used to mode shape variability in tangent space. We use the term "shape activity" to denote a continuous state stationary transformed features for shape deformation and scaled Euclidean motion in the activity. A "stationary shape activity" is defined as one for which the shape vector is stationary. The expected value of shape remains constant with time and the shape deformation model is stationary, while for a "stationary shape activity", the mean shape is time-varying). We have modeled the normal activity of passengers deplaning and moving towards the airport terminal. We use a stationary shape activity model for this case. It is good for accurately modeling normal behavior and detecting abnormality when the mean shape does not change much. It is very specific to the learnt activity and hence less robust to model error and unable to track abnormality. Shape can be a slow or drastic change in the shape dynamics and hence we use a combination of database classification and tracking error to detect it. The landmarks could be the various parts of a human body. Our framework can be used to learn models for the actions and detect and track abnormality in the action. This ability can be useful to medical professionals trying to analyze motion disorders in their patients. It would be useful, if software can detect the disorder and also provide its tracks to the medical professional. We use a stationary shape activity model for this application since it can track un-modeled shape changes. The result of proposed method is plotted in Fig. 2.

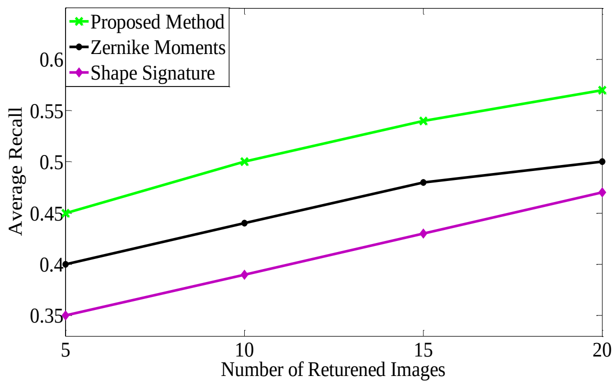

Figure 2 Average recall for different number of returned image from database

It is shown that proposed method is superior to pervious methods. It is thus able to track a large class of abnormal activities and yet detect them using database classification. Also for slowly varying shapes, we define a piecewise stationary shape activity model for which the mean shape is assumed to be piecewise constant. it can be used in conjunction with database classification for activity segmentation.

CONCLUSION

The goal of this research is to model an “activity” performed by a group of moving and interacting objects and use these models for shape detection, tracking. We treat the objects as point objects. We model the changing configuration of objects as a moving and deforming “shape”. A stochastic shape dynamical model is defined to represent a “normal activity”. Shape is defined as a change in the shape dynamics learnt for the normal activity. Previous approaches to modeling activity performed by groups of point objects include co-occurrence statistics and discrete state Dynamic Bayesian Networks. The simulation results prove that our method is more efficient than pervious methods.

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