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Implementation of Feature Based Object Identification in Bipedal Walking Robot

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Abstract: ***A bipedal walking robot resembles human. They are specifically programmed to perform some specific tasks. The field of Robotics is growing rapidly to serve military and commercial applications. Bipedal are capable of doing almost all crucial and critical tasks which are dangerous for humans. To fulfill this aim the bipedal should have a vision system. This system would help to identify the objects and the bipedal controller would be able to take actions. The present work deals with a vision based navigation (VBN) of bipedal. The bipedal identifies the object by using SURF algorithm. The action strategy of navigation is with the bipedal controller which uses Q-learning RL algorithm in dynamic environment. Bipedal identifies the object depending on the objective of its design or objects stored in database. This feature based Q learning RL algorithm helps in reducing the number of states values and also help in sharing and transferring the knowledge from one RL agent to another RL agent. Also useful for obstacle avoidance and identifying the dangerous objects while navigating.***

Index Terms /Keywords : Bipedal, Vision System, SURF, Object Identification, Feature Extraction, RL algorithm.

I. Introduction

Bipedal can perform tasks which are tough and unsafe for humans. Bipedal can assist human in the hazardous environmental conditions - fire rescue operation, chemical explosive. For performing such tasks the basic issue is vision sensing to the bipedal. Reduction in cost and accuracy to maintain data of the navigational sensor encouraged the rapid use of vision sensing. For many mission including visions are replacing cameras with these sensors. Navigation of the Bipedal is solely vision based, in which the matches are found for the online images captured by the imaging sensors. These matches are done using a set of features extracted from the current image and comparing them with the previous knowledge of the features. The algorithm used for the matching should be invariant of the scale and the rotation of the image captured. The algorithm commonly used is fast Speeded Up Robust Features (SURF) algorithm. The SURF algorithm is an speeded form of SIFT(Scale Invariant Feature Transform).

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II. VISION SYSTEM IN BIPEDAL WALKING ROBOT

Bipedal robots are self learning, self adaptive and have capabilities to face real situation and should be capable to perceive the changes in the environmental around them. The most challenging problem with the bipedal robot is about the action to be taken in current situation. While using Reinforcement Learning(RL) on bipedal as no model of the environment is present. RL helps biped to learn to map from present state to next actions by reward earned through interaction with their dynamic environment. The biggest challenge of using RL in Bipedal is large state-action space and the uncertainties in the dynamic environment and the reward.

The general control system initializes the state information and stores the online image capturing The vision system captures the images of the dynamic environment on a continuous basis (approximately after each millisecond). The current frames(picture) captured is compared with the previous frame(picture). The consecutive frame comparison is done. If there is difference between the frames then the information is passed to the image controller of bipedal.

The image controller then runs the object identification algorithm developed in this research work and discussed further. The object is identified in the dynamic environment. The strategy to follow in the environment is determined by the information provided by the vision system and the bipedal walking controller.

III. FEATURE BASED OBJECT IDENTIFICATION IN REINFORCEMENT LEARNING

The motivation of feature based is due to following reasons : 1) how to reduction the number of state values to be maintained in the Q learning RL algorithm 2) Use of these trained RL agents in much larger dynamic environment in real life. The benefits of using Feature based RL - identification of the object , planning the strategy accordingly, transferring of knowledge from one RL agent to another RL agent.

In Q learning RL algorithm the state values are based on some features of the surrounding environment. Information about similar object present and how to deal with them can be transferred from one agent to another. For Example, If in the dynamic environment there is stair and the height of stairs is fixed then what action should be taken to climb the stairs can be shared between the RL agents. If for a soccer robot we have to kick the ball the identification of soccer ball in the soccer field is the knowledge which can be shared between agents.

Two approaches to implement feature based object identification are :

1)Simple encoding method used to change the RL agent's immediate environment

2)Apply object identification(Image processing) algorithms and then identify the objects.

In this paper , second approach is used to identify objects. The object identification is done by SURF algorithm discussed in next section.

A. *Speeded-Up Robust Feature (SURF)*

SURF is a robust image detector and descriptor. Descriptor is based on approximated Hessian matrix. The descriptor gives the distribution of Haar-wavelet responses within the neighborhood of interest points.

Due to low dimensionality of descriptor, the detector and descriptor both reduces the time of computation. Speed, Robustness , distinctiveness and repeatability characteristics of SURF make it a better choice than other existing methods. Basic Hessian matrix approximation is used for interest point detection. This determinant determines the scale and location of the descriptor. Box lets framework is used for the integral images. In the steps to extract SURF descriptor for an image - the information based on orientation of area around the interest points is used. These areas are circular in nature, Haar wavelet is used to compute orientation in X and Y direction summing up Gaussian weights are used for the horizontal and vertical responses, maximum value defines the orientation of descriptors of interest points. Image scales are used as scale spaces. The Gaussian is used to smoothen the images iteratively and sub sampling results in reaching at higher level of the pyramid. Repeated applying of filter is prevented by use of integral images and box filters. Analysis of scale space is by up scaling the filter size. An octave which is division of scale spaces, is a sequence of response maps. These are achieved by combining the same input image and applying the filter of increasing size. each octave has a constant number of level of scales.

The sign of Laplacian , computed in the detection is used for interest points. The sign of the Laplacian distinguishes bright blobs on dark backgrounds from the reverse case. In case of matching the features are compared only if they have same type of contrast (based on sign) which allows faster matching [7].

B. *Advantages of SURF over SIFT*

SURF is faster than SIFT in real time application. It has low dimensionality as compared to SIFT. It reduces the computation time.

TABLE I: A SUMMARY OF THE STATE-OF-THE-ART FEATURE DETECTORS [6]

Category	Classification	Methods and Algorithms
Edge-based	Differentiation based	Sobel, Canny
Corner-based	Gradient based	Harris (and its derivatives), KLT, Shi-Tomasi, LOCOCO, S-LOCOCO
Corner-based	Template based	FAST, AGAST, BRIEF, SUSAN, FAST-ER
Corner-based	Contour based	ANDD, DoG-curve, ACJ, Hyperbola fitting, etc.
Corner-based	Learning based	NMX, BEL, Pb, MS-Pb, gPb, SCG, SE, tPb, DSC, Sketch Tokens, etc.
Blob (interest point)	PDE based	SIFT (and its derivatives), SURF (and its derivatives), CenSurE, LoG, DoG, DoH, Hessian (and its derivatives), RLOG, MO-GP, DART, KAZE, A-KAZE, WADE, etc.
Blob (key point)	Template based	ORB, BRISK, FREAK
Blob (interest region)	Segmentation based	MSER (and its derivatives), IBR, Salient Regions, EBR, Beta-Stable, MFD, FLOG, BPLR

IV. PROPOSED SYSTEM

The proposed system has two main parts where the processing is carried out. They are : Feature processing and Q -learning RL algorithm. The feature processing includes the feature extraction . feature matching and object identification. The resultant processed state(s_p) is then input to the Q learning algorithm then the action a_t is taken in the dynamic environment the resultant is the next state (s_{t+1}) along with the dynamic reward generation (r_{t+1}). The next state(s_{t+1}) is then input to the Feature processing through delay and the reward generated (r_{t+1}) is input to the Q-learning RL algorithm through a delay.(Figure 1)

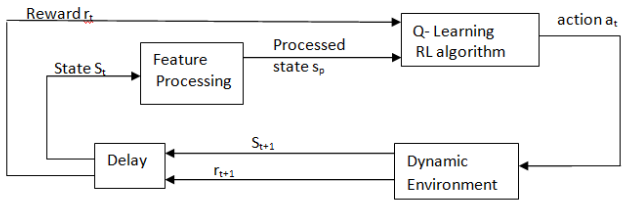

Figure 1 *Architecture of feature based RL agent*

V. EXPERIMENTAL RESULTS

Figure 2 shows the image to be compared of the soccer ball. The colored image is converted to gray image then 200 strongest points were identified which help in feature matching.

Figure 2. *Soccer ball with 200 strongest points identified*

Figure 3 shows the image of the ground where the ball is present the colored image is first converted to gray scale image then 400 strongest point were identified which help in feature matching. The strongest point identification reveals that the ball has more points identified and less on the ground.

Figure 4 matches the features obtained from figure 2 and figure 3 .The left side is the figure 2 strongest point image and right hand side is figure 3 strongest point identified image. These two images are affine feature matched the top figure shows including outliers on SURF algorithm and the lower figure shows including only inliers on SURF algorithm.

Figure 5 shows the ball identification on the ground in both the gray and the colored image. Hence the feature is processed and the result is the state(position) of the soccer ball on the ground

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Figure 3 *Soccer ball on the ground, its gray image and 400 strongest points identified*

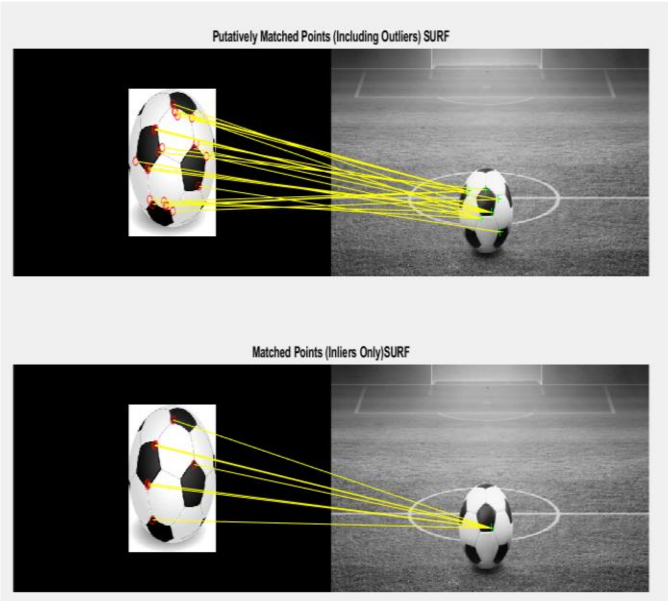

Figure 4 ***Top*** *Matched points including outliners on SURF algorithm* ***Bottom*** *Matched point including only inliers on SURF algorithm*

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Figure 5 *Soccer ball identification done in gray and color images*

The soccer ball is identified on the ground. The position of the ball is calculated and passed to the Q-learning RL algorithm. The controller then send the instruction to the bipedal joints to make movement to reach the soccer ball accordingly.

VI. CONCLUSION

The current work includes the object identification in the dynamic environment. The bipedal vision controller uses this algorithm to extract features of different objects store in its database. After getting the change frame from the environment the bipedal identifies the difference in the frames obtained. Bipedal identifies the object and then take actions accordingly. In this application bipedal has to identify the soccer ball and then reach near it to kick the ball. The strategy is then followed by bipedal walking controller. The application of this algorithm is - Obstacle avoidance component of a robotic navigation system, Landmark recognition in navigation system and object identification in robot gaming or navigation.

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