Automated Visual Surveillance of a Population of Nesting Seabirds

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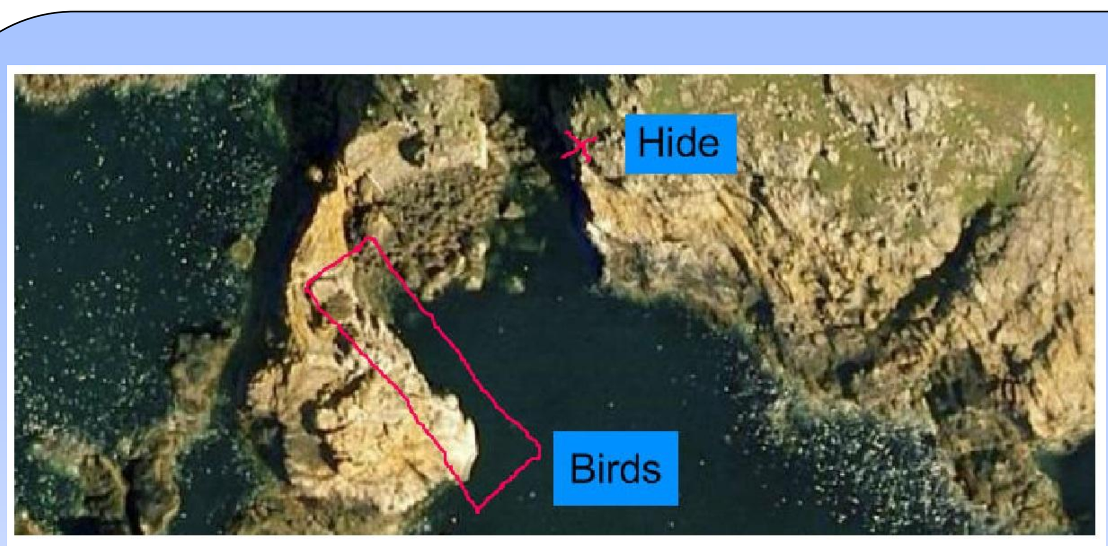
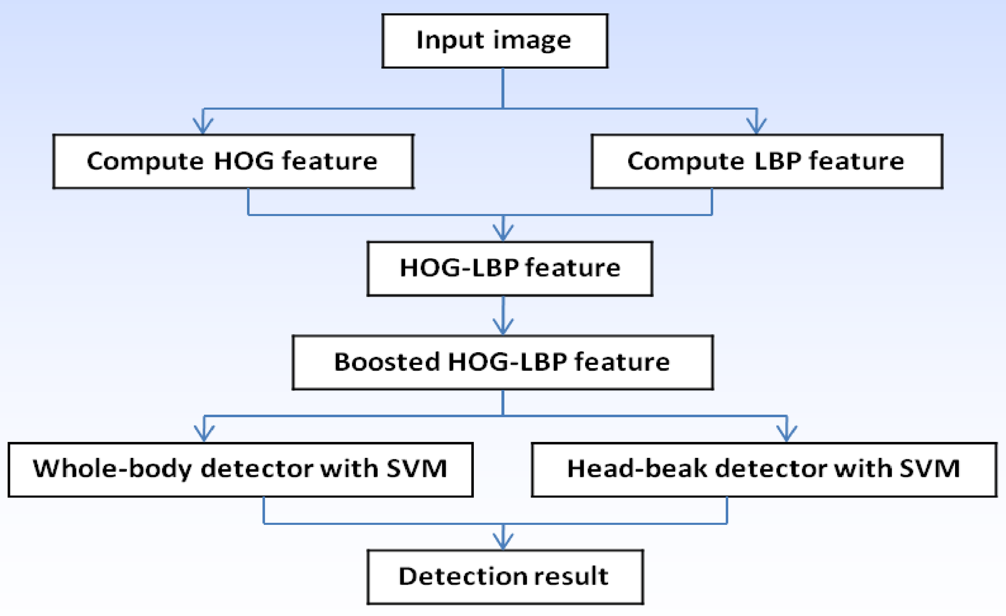
Introduction:

Seabird populations are a valuable and accessible indicator of marine health: population changes have been linked with fish stock levels, climate change, and pollution. Understanding the development of particular colonies requires detailed data, but manual collection methods are labour intensive and error prone. Our work is concerned with development of computer vision algorithms to support autonomous visual monitoring of cliff-nesting nesting seabirds, and collection of behavioural data on a scale not feasible using manual methods. This work has been conducted at the University of Lincoln (UK), in collaboration with the Centre for Computational Ecology and Environmental Science (CEES) at Microsoft Research Cambridge. Our work has been ongoing for around 12 months, and focused on robust image processing techniques capable of detecting and localizing individual birds in image and video data. In our case, we are using data captured from a population of Common Guillemots (Uria aalge) resident on Skomer Island, West Wales (UK) during the summer of 2010. This work represents a unique adaptation of computer vision technology, and we present a discussion of current and future technical challenges, processing techniques which we have developed, and some preliminary evaluation and results. In particular, we consider techniques based on feature based detection of birds and their body parts using gradient image features.



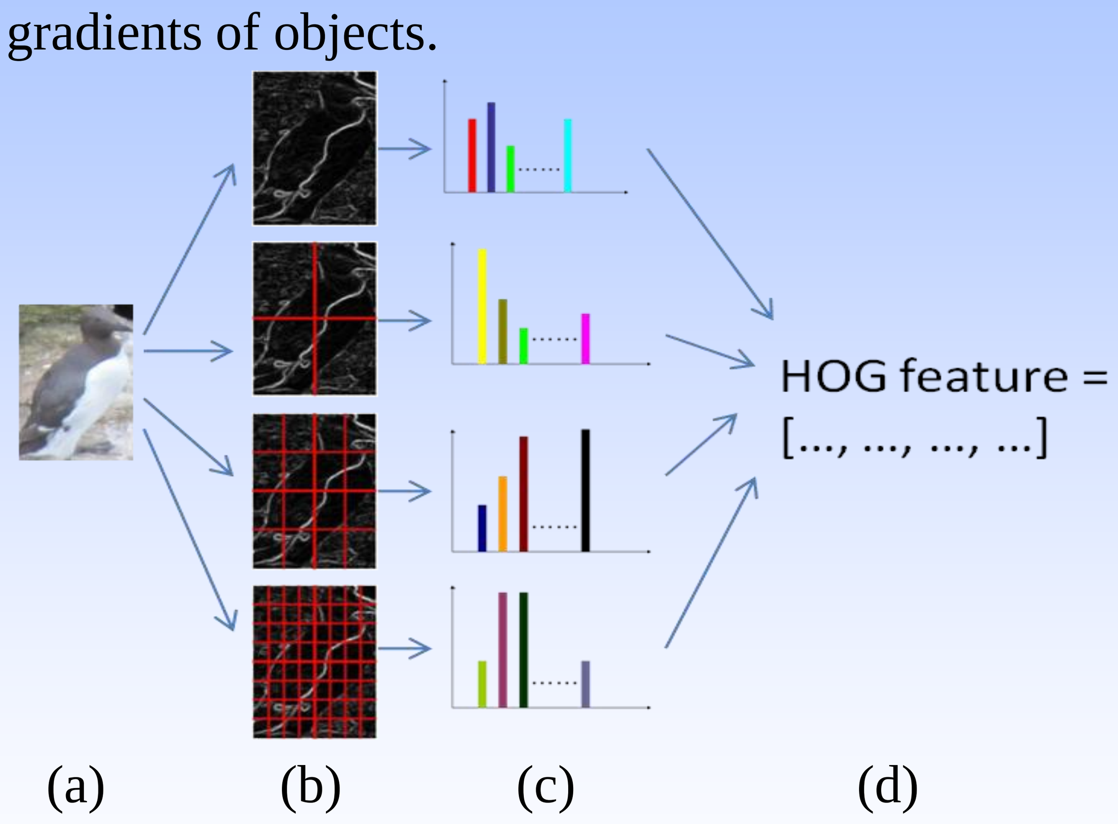
"The Amos" Skomer Island, and hide position



The framework of seabirds detection

Histograms of Oriented Gradients (HOG)

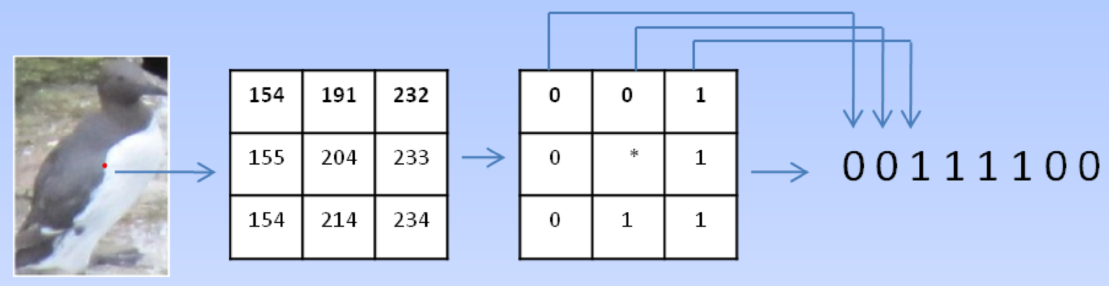
HOG is an excellent descriptor for capturing the edge direction or the distribution of local intensity gradients of objects.



The procedure of the feature extraction of the four level HOG. (a) Input image. (b) Block division at four levels of the gradient magnitude. (c) Histograms of each level. (d) Final HOG feature

Local Binary Pattern (LBP)

LBP is an excellent texture descriptor for its invariance to gray-scale and rotation.



An illustration of the $LBP_{8,1}^{u2}$ pattern calculation

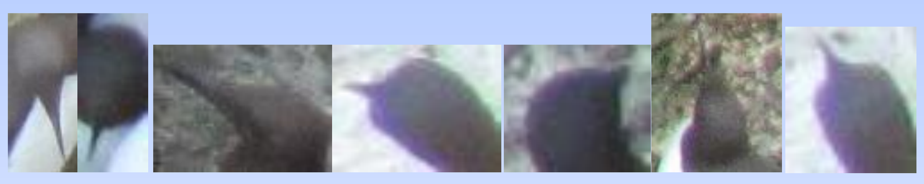
The value of the LBP code of a pixel (x_c, y_c) is given by:

$$LBP_{P,R} = \sum_{p=0}^{P-1} s(g_p - g_c)2^p \qquad s(x) = \begin{cases} 1, if\ x \geq 0; \\ 0, otherwise. \end{cases}$$

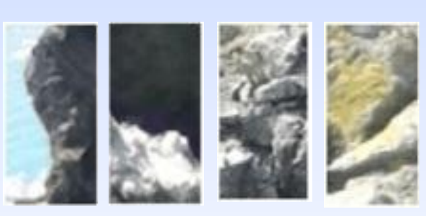
Boosted HOG-LBP feature

AdaBoost is used to reduce the dimension of the HOG-LBP feature space, obtain the most discriminating features of seabirds suitable for the SVM classifier, and decrease the computation cost in SVM classification.

Positive samples from whole-body dataset



Positive samples from head-beak dataset



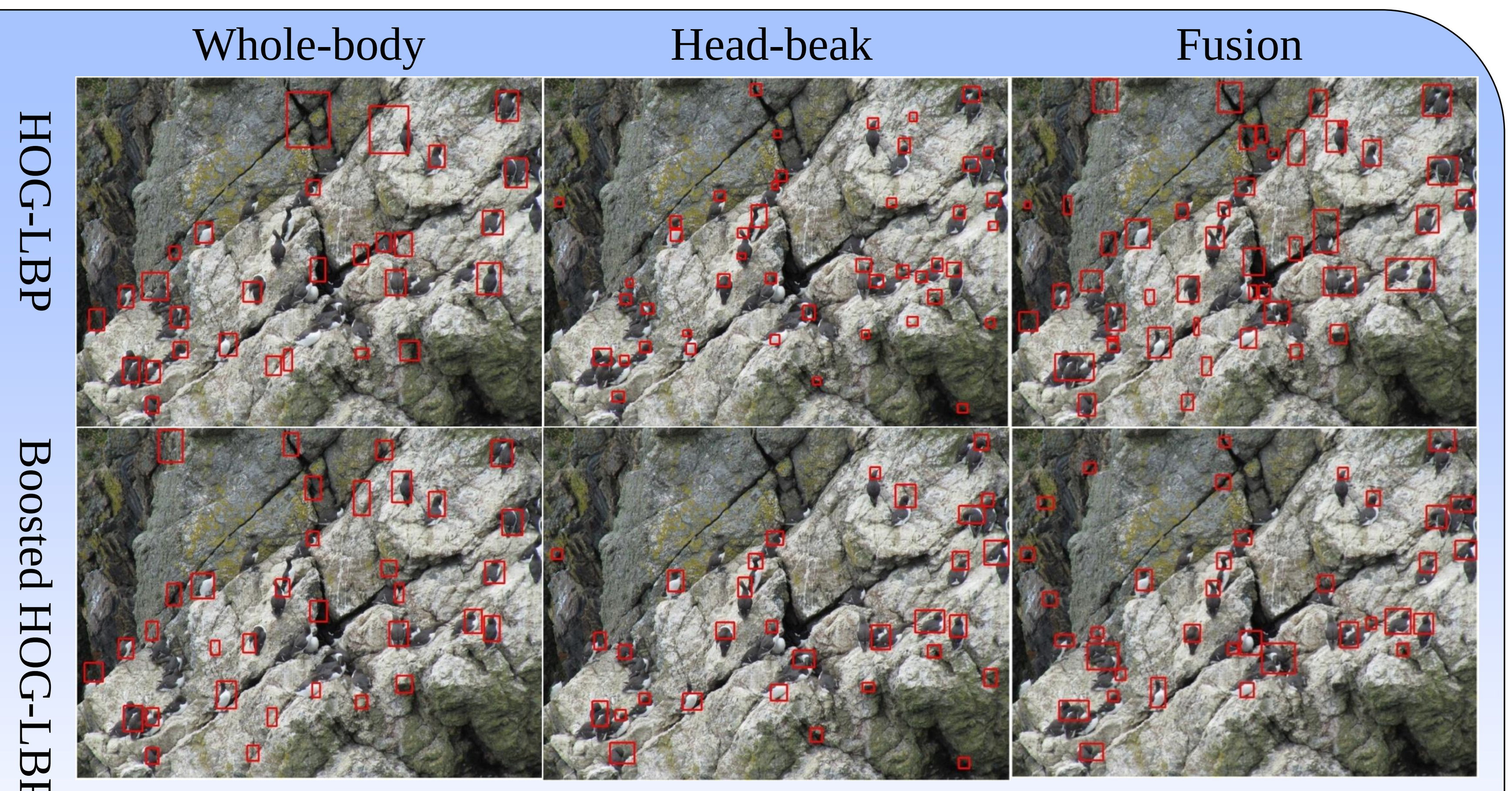
Negative samples

Data Collection

Digital still image cameras capture a still image approximately every 5 seconds.

Training Processing

Whole-body dataset: (48x64 pixels) 5000 positive seabird patterns and 6000 negative examples.
Head-beak dataset: (32x32 pixels) 2000 positive bird head samples and 6000 negative samples.
Classifier: linear SVM (c=1)



During testing, each image sequence is densely scanned from the top left to the bottom right with rectangular sliding windows in different scales. We perform the detection for each single image at 10 scales without considering any temporal smoothing. We use the detection rate (DR) and feature number (FN) to evaluate the detection results. The fusion of the whole-body detector and the head-beak detector get the best performance based on the boosted HOG-LBP feature.

Detection Results

		Whole-body	Head-beak	Fusion
HOG-LBP	DR	64.8%	67.1%	76.7%
	FN	8075	8075	8075
Boosted	DR	69.5%	71.9%	79.1%
HOG-LBP	FN	300	300	300

Conclusions:

1. A novel detection system for monitoring a specific population of Common Guillemots on Skomer Island, West Wales (UK) is proposed based on a novel augmented feature, called boosted HOG-LBP, which boosts four level HOG and LBP to provide the global and local description of objects.
2. A comparative study of two kinds of detectors is presented, i.e., whole-body detector, head-beak detector, and results obtained by fusing them.
3. The ongoing work integrates a foreground segmentation module to obtain the active areas in the observed area and the detection module to detect guillemots from the detected foreground areas. It is believed that false positive samples can be largely eliminated and detection can be speeded up.
4. Future work includes incorporating motion information using block matching or optical flow fields, looking for image descriptors that are more robust against illumination and other factors, and provisioning detailed population-level data about nesting seabirds, in a non-intrusive manner.

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