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Camouflaged Object Sensing Using Deep Learning Approach

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Agenda

- Introduction
- Literature Survey
- Existing System
- Problem Statement
- Proposed System
- Applications
- References

Introduction

- Object detection is the fundamental component of optical sensor systems

- However, it is very challenging to apply object detection techniques in harsh or extreme situations that are even challenging to the naked eye

- A typical example is to identify species with camouflage capabilities from images acquired by non-invasive sensors i.e. camera traps

Image of
camouflaged leopard

Introduction

- Limited imaging quality of the sensors and the illuminance conditions, objects often show similarities in color and texture with the background
- Challenging tasks like these are solved using *camouflaged object detection* (COD)
- *Camouflage* is the phenomenon of visual concealment that exists extensively in both natural and artificial objects
- COD focuses on targets that are less likely to capture human attention or attempt to deceive visual perception systems in an adversarial manner

Introduction

- COD is based on saliency from the human perspective

- Traditional approach -

1. *Salient Object Detection (SOD)* detects targets that grab human attention.

Drawback - SOD performs model saliency and salient objects tend to be visually distinct from the surroundings. Thus SOD could not find the vague boundaries of objects and thus are not competent to accurately detect camouflaged objects

Introduction

- Traditional approach -

2. *Camouflaged object detection* (COD) was also often approached as foreground detection, which utilizes the hand-crafted features computed by edges, brightness, corner points, texture, or temporal information to separate the camouflaged object and the background.

Drawback - The hand-crafted features are incapable of detecting all the sophisticated camouflage strategies in the real application scenarios

Literature Survey

Anabranch network for camouflaged object segmentation Authors - T.N. Le, T.V. Nguyen, Z. Nie, M.T. Tran, Sugimoto

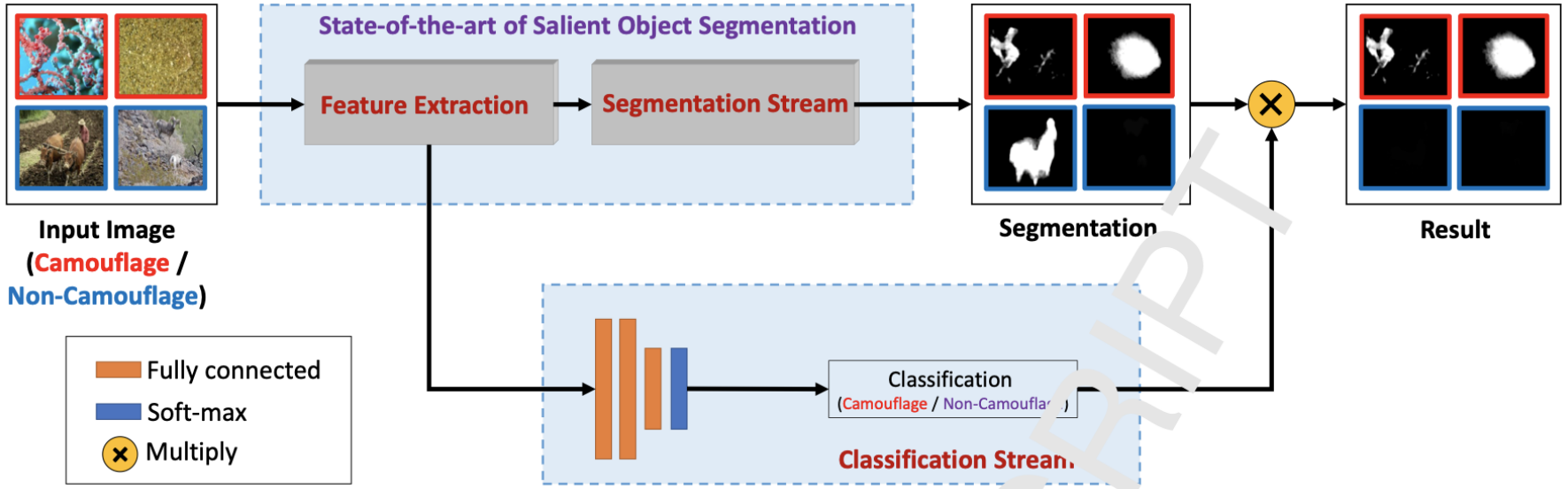
Year Published - 2019

- Overview – This paper proposes an ANet model that uses an additional classification networks to refine the prediction results of traditional target segmentation networks. The proposed network leverages the strength of both image classification and semantic segmentation tasks for camouflaged object segmentation
- Drawback – Its a two-stream structure that is based on the traditional convolutional network structure and, thus, cannot provide the perceptual ability required by the COD task

Literature Survey

Anabranch network for camouflaged object segmentation

Proposed Architecture –



Literature Survey

Simultaneously localize, segment and rank the camouflaged objects

Authors - Yunqiu Lv, Jing Zhang, Yuchao Dai, Aixuan Li, Bowen Liu, Nick Barnes, Deng-Ping Fan

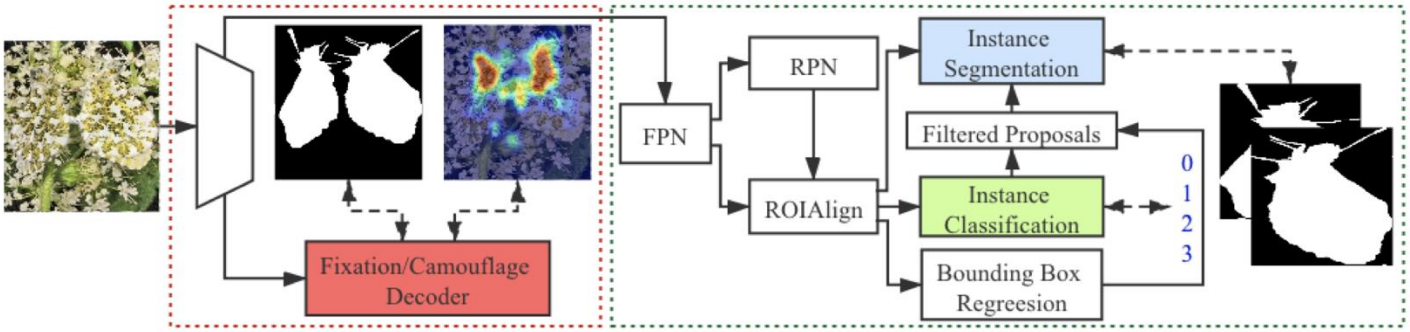
Year Published - 2021

- Overview – This paper proposes the RankNet architecture that generates saliency prediction by instance-level ranking-based region. RankNet uses the localization model to find the discriminative regions and the segmentation model to segment the full scope of the camouflaged objects.

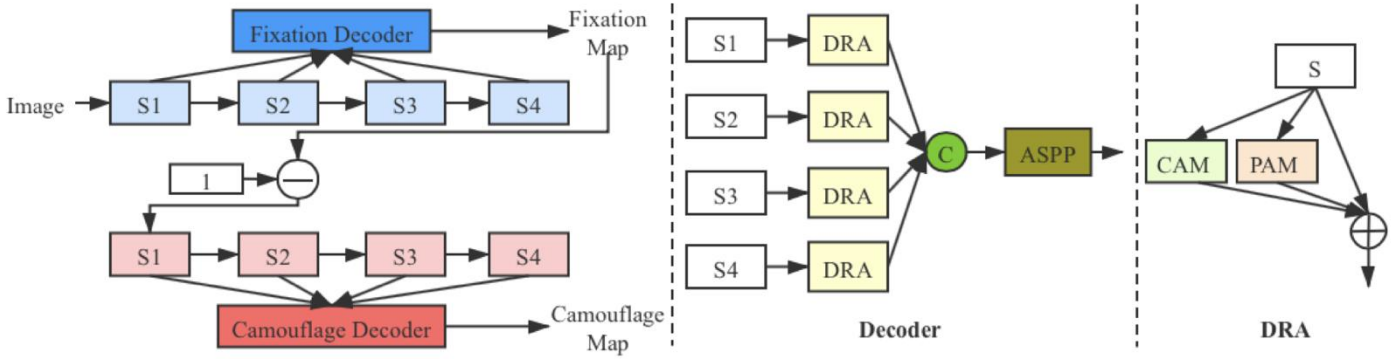
Literature Survey

Simultaneously localize, segment and rank the camouflaged objects

Proposed Network-



Overview of the joint fixation and segmentation prediction network -



Literature Survey

Camouflaged object detection

Authors – Deng-Ping Fan, Ge-Peng Ji, Guolei Sun, Ming-Ming Cheng, Jianbing Shen, Ling Shao

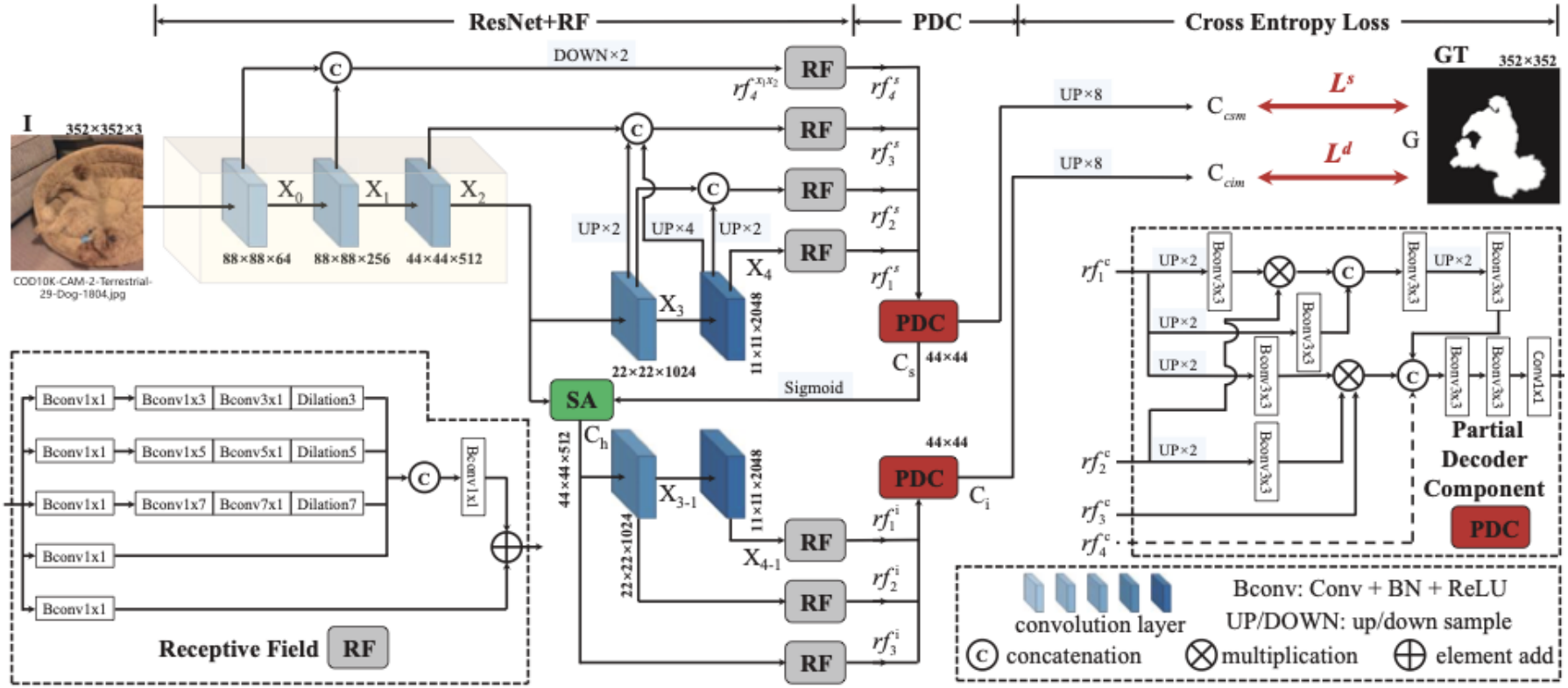
Year Published - 2020

- Overview – In this paper the authors propose a SINet architecture that utilizes a cascaded network, which divides the network into a Search Module (SM) and an Identification Module (IM), to hierarchically refine the prediction map. SINet also uses cascaded partial decoder as decoders.
- Drawback – PDC mixes features by addition and concatenation which is not robust enough to deal with low signal-to-noise ratio features obtained due to the lack of semantic orientation from shallow encoder layers

Literature Survey

Camouflaged object detection

Proposed Network -



Literature Survey

A Bayesian approach to camouflaged moving object detection

Authors –Xiang Zhang, Ce Zhu, Shuai Wang, Yipeng Liu,

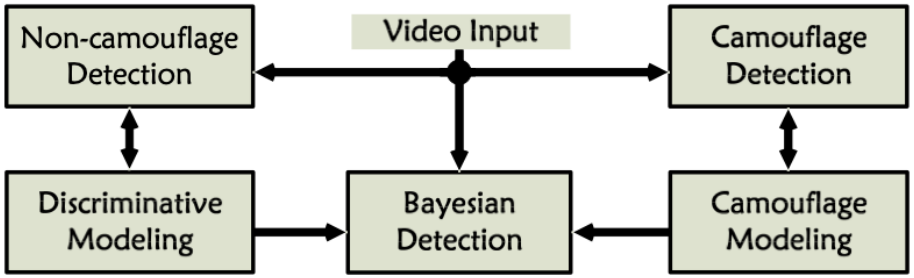
Year Published - 2016

- Overview – The paper focuses on the detection of moving camouflaged objects. It proposes camouflage modeling (CM) to identify camouflaged foreground pixels. Since, moving object is usually composed of both camouflaged and non-camouflaged areas, CM and discriminative modeling (DM) are fused in a bayesian framework to perform complete object detection.
- Drawback - Utilizes low-level features like texture, edge, brightness, and color to discriminate objects. These features are incapable of detecting all the sophisticated camouflage strategies in the real application scenarios

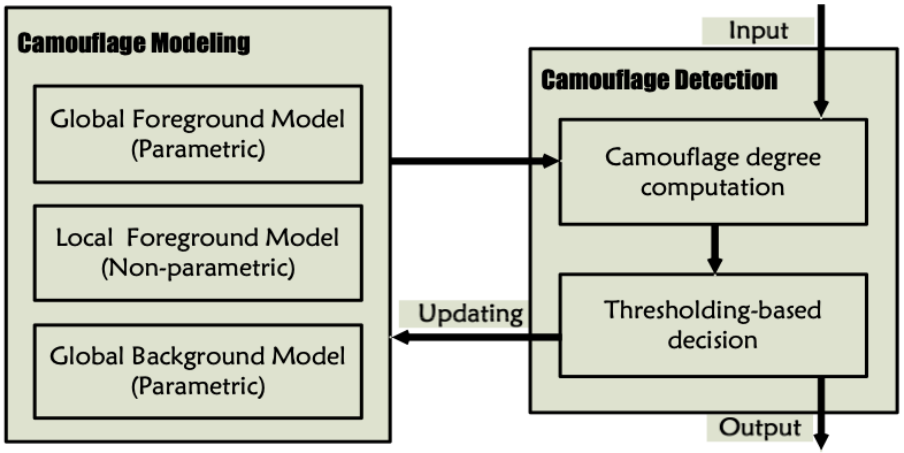
Literature Survey

A Bayesian approach to camouflaged moving object detection

Proposed Approach -



The components of the CM and associated camouflage detection -



Literature Survey

Foreground detection in camouflaged scenes

Authors – Shuai Li, Dinei Florencio, Yaqin Zhao, Chris Cook, Wanqing Li

Year Published - 2017

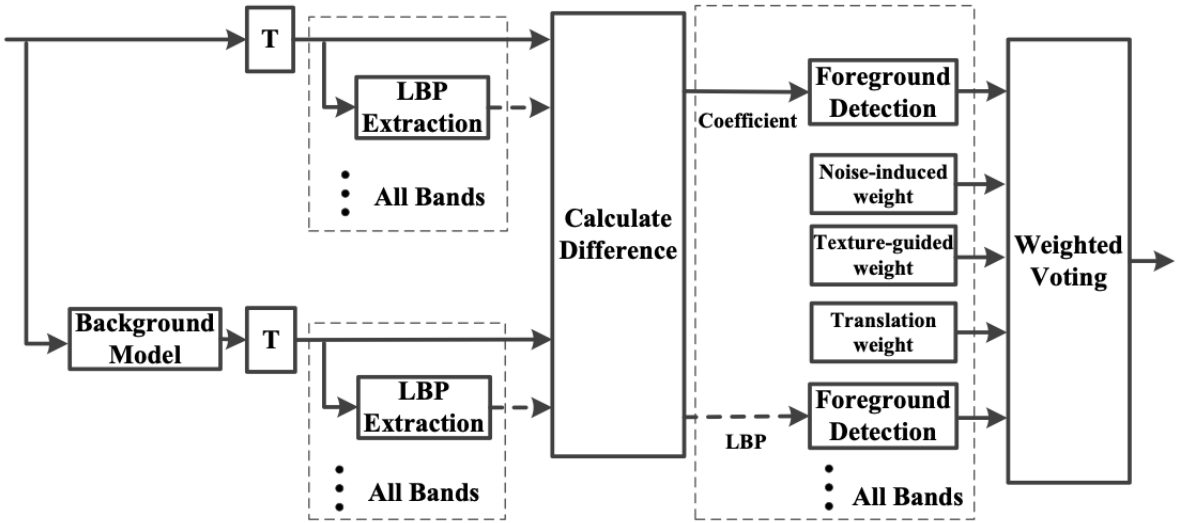
- Overview – This paper proposes a texture guided weighted voting (TGWV) to detect foreground objects in camouflaged scenes. The proposed method uses the stationary wavelet transform to decompose the image into frequency bands shows that the small and hardly noticeable differences between foreground and background in images can be captured in certain wavelet frequency bands. To make the final foreground decision, a weighted voting scheme is developed based on intensity and texture of all the wavelet bands with weights carefully designed.

Literature Survey

Foreground detection in camouflaged scenes

- Drawback – The computational complexity of the proposed method is higher due to the multiple level wavelet decomposition

Proposed Framework -



Literature Survey

Mutual Graph Learning for Camouflaged Object Detection

Authors – Qiang Zhai, Xin Li, Fan Yang, Chenglizhao Chen, Hong Cheng, Deng-Ping Fan

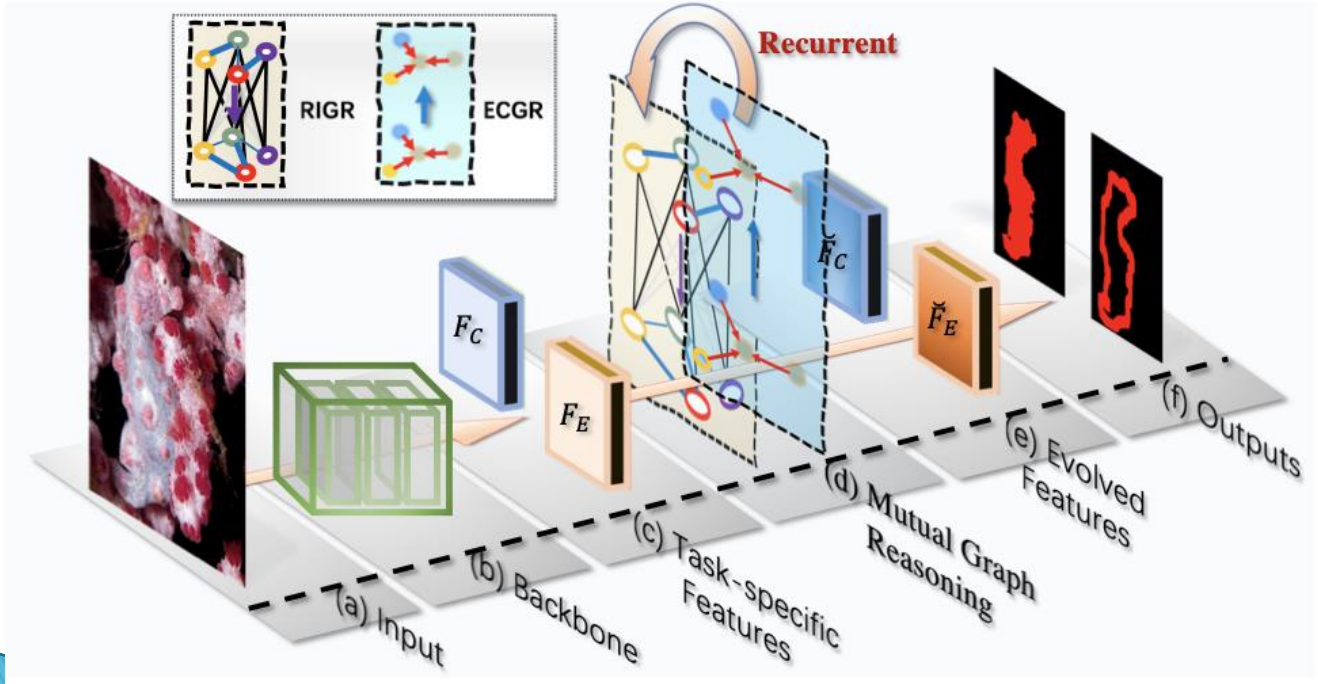
Year Published - 2021

- Overview – The paper proposes a Mutual Graph Learning (MGL) model which decouples an image into two task-specific feature maps - one for roughly locating the camouflaged target and the other for accurately capturing its boundary details and exploits the mutual benefits by recurrently reasoning their high-order relations through graphs.
- Drawback – The paper considers edge disruption as one of the key factors for camouflage which may not be the case in all situations

Literature Survey

Mutual Graph Learning for Camouflaged Object Detection

Proposed Framework -



Literature Survey

Mirror-net: Bio-inspired adversarial attack for camouflaged object segmentation

Authors – Jinnan Yan, Trung-Nghia Le, Khanh-Duy Nguyen, Minh-Triet Tran, Thanh-Toan Do, Tam V. Nguyen

Year Published – 2021

- Overview – The paper proposes a MirrorNet architecture that uses instance segmentation and mirror stream for the camouflaged object segmentation. The proposed network possesses two segmentation streams: the main stream and the mirror stream corresponding with the original image and its flipped image, respectively. The output from the mirror stream is fused into the main stream's result for the final camouflage map to boost up the segmentation accuracy.

Literature Survey

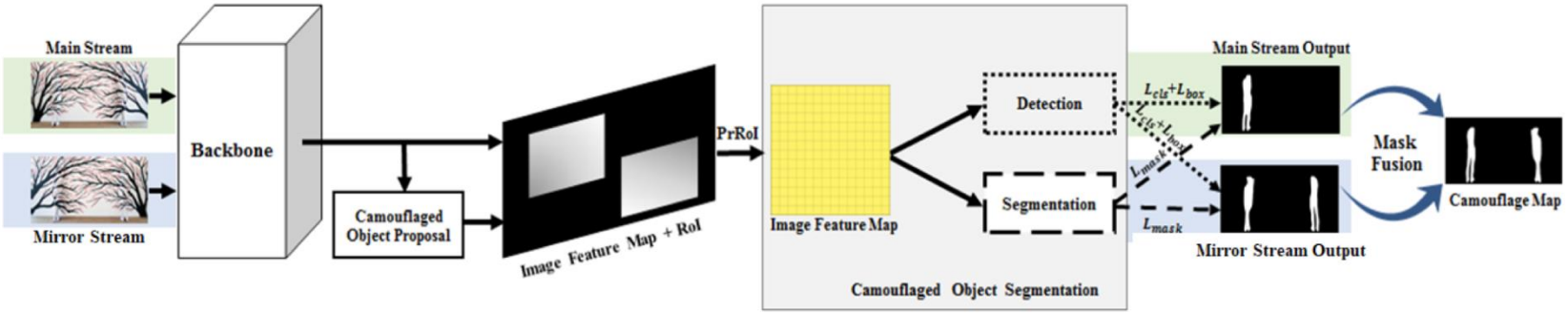
Mirror-net: Bio-inspired adversarial attack for camouflaged object segmentation

- Drawback – Its a bio-inspired model that mimics the perception and cognition of observers. However, it ignores an important attribute, the time that observers spend on searching for the camouflaged object varies in wide range and heavily depends on the effectiveness of camouflage. Therefore, the model fails to consider that the features employed to detect the objects are also different when they have different camouflage degrees.

Literature Survey

Mirror-net: Bio-inspired adversarial attack for camouflaged object segmentation

Proposed Framework -



Literature Survey

Camouflaged Object Segmentation with Distraction Mining

Authors – Haiyang Mei, Ge-Peng Ji, Ziqi Wei, Xin Yang

Year Published – 2021

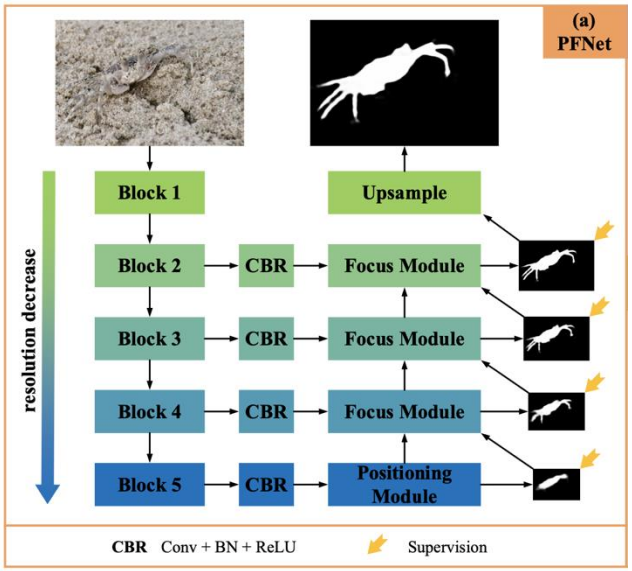
- Overview – This paper proposes Positioning and Focus Network (PFNet), which mimics the process of predation in nature. PFNet contains two key modules, the positioning module (PM) and the focus module (FM). The PM is designed to mimic the detection process in predation for positioning the potential target objects from a global perspective and the FM is then used to perform the identification process in predation for progressively refining the coarse prediction via focusing on the ambiguous regions. In the FM, distraction mining strategy is used for the distraction discovery and removal, to benefit the performance of estimation.

Literature Survey

Camouflaged Object Segmentation with Distraction Mining

- Drawback – In case of higher-level prediction, the performance of the network would decline to some extent as indiscriminately mining distractions from the input features increases the difficulty of the distraction discovery and thus hinders the effective distraction removal.

Proposed Framework -



Literature Survey

Camouflage performance analysis and evaluation framework based on features fusion

Authors – Feng Xue, Chengxi Yong, Shan Xu, Hao Dong, Yuetong Luo, Wei Jia

Year Published – 2016

- Overview – This paper proposes a framework that uses nonlinear fusion of multiple image features to quantitatively evaluate the degree to which the target and surrounding background differ with respect to background-related and internal features. Background-related features are first formulated as a measure of saliency, which is calculated and quantized by SOD, whereas internal features refer to the interior saliency of camouflage textures, such as lines and other regular patterns. These two features are fused to identify and evaluate the camouflage effect.

Literature Survey

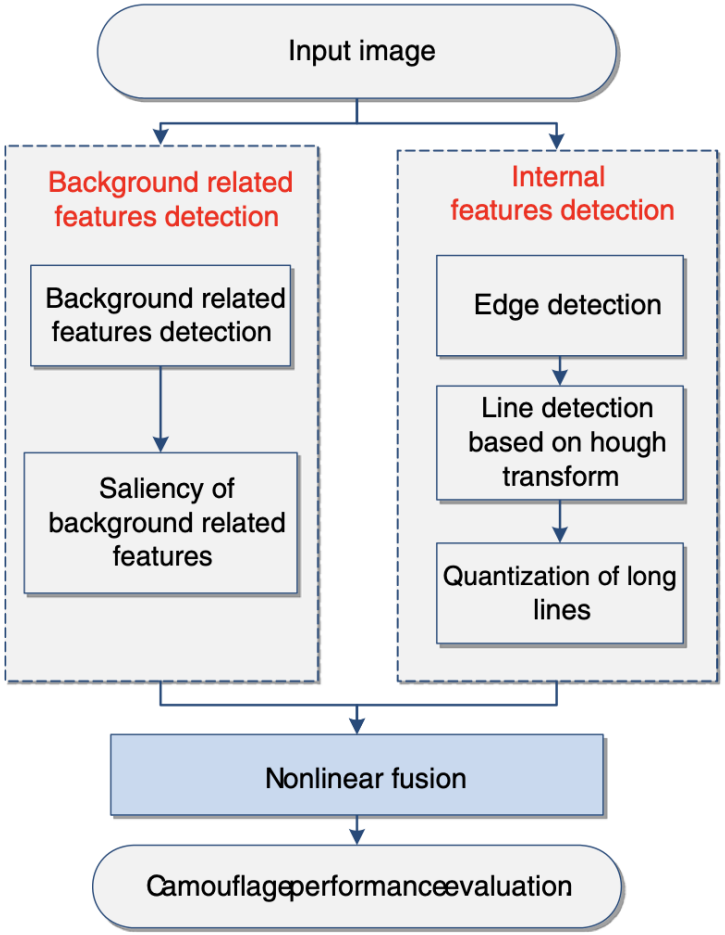
Camouflage performance analysis and evaluation framework based on features fusion

- Drawback – SOD requires objects to be visually distinct from the background and does not specialize in finding the vague boundaries of objects. Considering internal features of camouflaged objects may not be robust in case of sophisticated camouflage strategies in the real application scenarios

Literature Survey

Camouflage performance analysis and evaluation framework based on features fusion

Proposed Framework -



Existing System

Existing COD systems are encoder-decoder based models that use encoder to extract features and decoder to fuse features

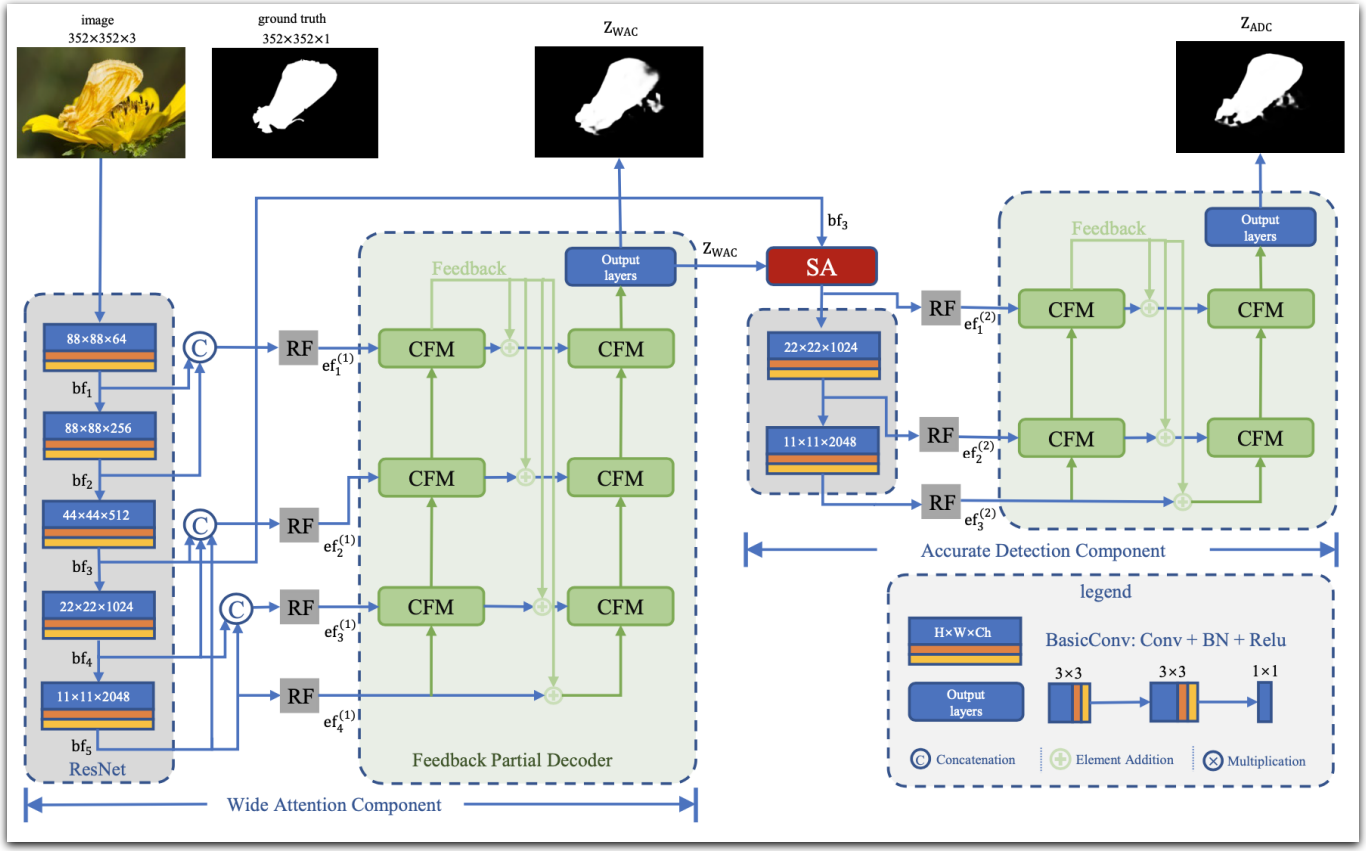
The drawbacks of above architecture

- difficulty in accurately estimating the detection map
- output features of the shallow encoder layers have a low signal-to-noise ratio due to the lack of semantic orientation which affects the decoding process adversely
- decoder is vulnerable to large background noise produced by camouflaged targets which leads to vague target boundaries and misjudgment in extreme situations

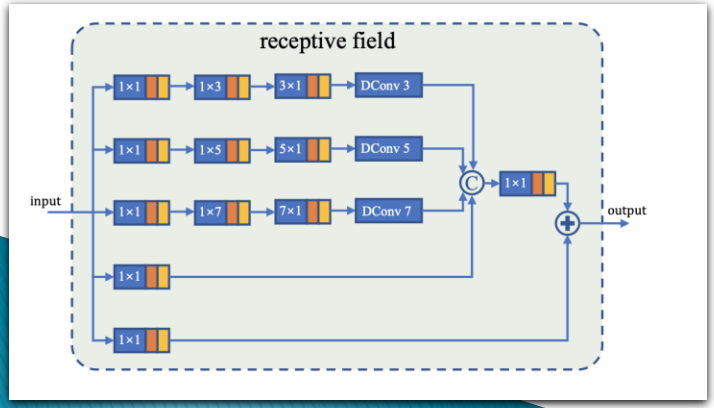
Problem Statement

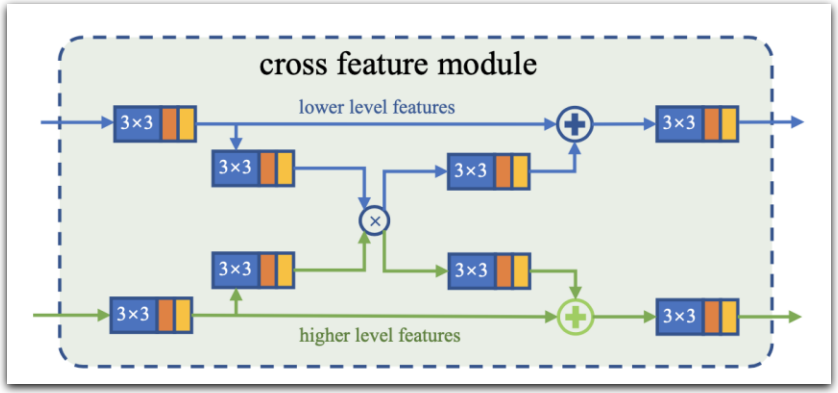
Camouflaged Object Sensing using Deep Learning

Proposed System



Overview of the CODCEF framework





Applications

- Camouflaged object detection (COD) is a critical object detection technique in biological, security, and military scenarios
- COD is used to identify species with camouflage capabilities from images acquired by non-invasive sensors
- COD is beneficial for applications in the fields of computer vision (for search- and-rescue work, or rare species discovery)
- COD is used for medical image segmentation (e.g., polyp segmentation, lung infection segmentation)
- COD is used in the agricultural domain for applications like locust detection
- COD is used in the art field for photo-realistic blending, recreational art, etc.

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THANK YOU