A CASCADE OF CNN AND LSTM NETWORK WITH 3D ANCHORS FOR MITOTIC CELL DETECTIONIN4DMICROSCOPICIMAGE

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BACKGROUND & CONTRIBUTATION

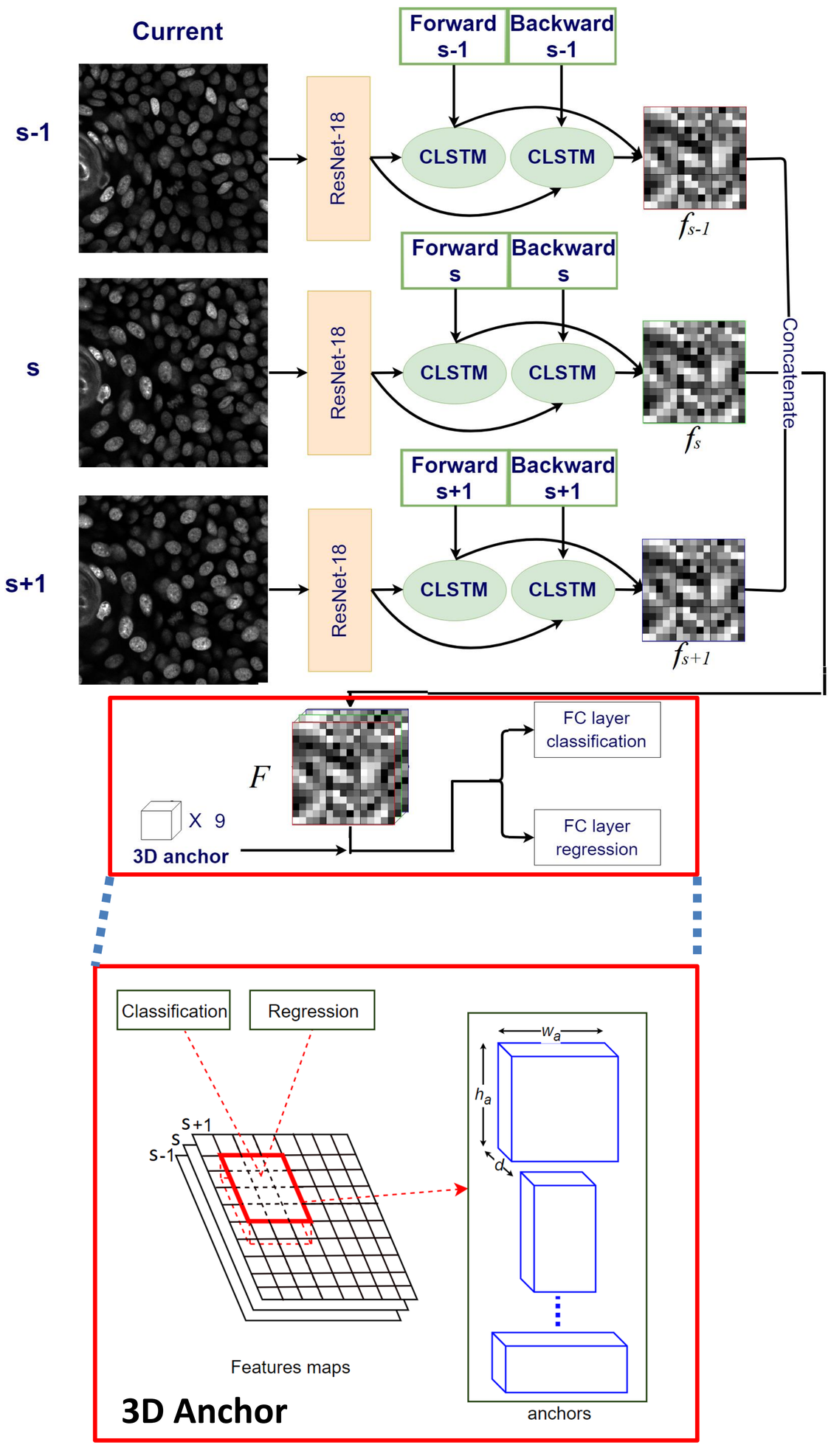
Background & Problems

- Mitotic can be used to understand cell behaviors, analyze diseases, and in many biomedical applications.
- Detection methods are done on 2D image and problem occur on those methods
  - The mitosis event not occur only on x-y plane
  - Mitotic cell may move from outside of the capture screen

Contribution

- Propose 3D anchors for 4D mitotic detection
  - Reduce false negative results
  - Able to detect oriented mitotic cells
- Combine CLSTM to include temporal information
  - significantly reduce false positive results

Proposed Deep Network Architecture (CasDetNet_LSTM_3D Anchor)



METHODOLOGY

Two Main Parts of Our Network

2.5D Method for Feature Extraction

- Each slice (s) generated feature map (f_s).
- Considering the temporal information by using bidirectional CLSTM.

3D Anchors for Mitotic Cell Prediction

- Merging spatial information from nearby slices (f_{s-1}, f_s, f_{s+1})
- Generate prediction result by using 3D anchors for slice (s)

POST PROCESSING

- Refine our network results
- Remove erroneously identified
- Adding missing mitotic cells
- Using both spatial and temporal
- information

$$\delta_{s+j,i}^{t+k} = \begin{cases} 1, & \text{if } C_{s+j,i}^{t+k} \geq 0.5 \\ 0, & \text{else} \end{cases}$$

$$W_{s+j,i}^{t+k} = 1 - \frac{\sqrt{j^2+k^2}}{\sqrt{N^2+T^2}}$$

$$\hat{C}_{s+j,i}^{t+k} = \frac{\sum_{j=-N}^{N}\sum_{k=-T}^{T} W_{s+j,i}^{t+k}\delta_{s+j,i}^{t+k}}{\sum_{j=-N}^{N}\sum_{k=-T}^{T} W_{s+j,i}^{t+k}}$$

DATASET

Dataset information

- From TC-IAIPA-IA2017
- 16 set of 4D data
- 80 temporal frames
- Size: 480x480x37

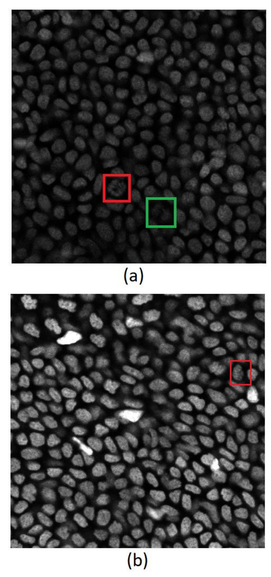
Data augmentation

- 1-3 mitotic cell(s)
- Rotated 15°
- Scale 0.8~1.2

RESULT

Table 1. Quantitative comparison of our proposed methods and conventional methods for 2D image slices.

Method	Precision	Recall	F1 Score
2D Faster R-CNN [14]	0.0870	**0.9310**	0.509
3D Faster R-CNN	0.0592	0.4143	0.2367
SSD [15]	0.0411	0.7221	0.3816
HCNN [9]	0.7003	0.6910	0.6957
TS-BLSTM [10]	0.7883	0.7751	0.7817
2.5D Faster R-CNN [11]	0.3591	0.7532	0.5562
CasDetNet_CNN [11]	0.7228	0.70358	0.7132
CasDetNet_LSTM	0.8195	0.7974	0.8085
CasDetNet_LSTM_3DAnchor	**0.8356**	0.8442	**0.8399**


(a)

(b)

Table 2. Detection results on 4D images to observe the orientation robustness.

Data		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Sugano[16]	TP	1	1	2	3	2	1	0	1	2	2	1	1	0	2	2	2
	FN	0	0	0	0	1	0	1	0	0	0	1	2	1	0	0	0
	FP	0	3	0	0	0	0	0	0	0	9	0	0	0	1	17	6
Faster RCNN[14]	TP	1	1	2	3	3	1	1	1	2	2	2	3	0	2	2	2
	FN	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
	FP	8	5	9	12	16	4	4	7	8	7	6	9	8	4	15	11
CasDetNet_LSTM	TP	1	1	2	3	1	1	1	1	1	2	1	1	0	2	2	2
	FN	0	0	0	0	2	0	0	0	1	0	1	2	1	0	0	0
	FP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CasDetNet_LSTM_3DAnchor	TP	1	1	2	3	1	1	1	1	2	2	2	3	1	2	2	2
	FN	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	FP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ground truth		1	1	2	3	3	1	1	1	2	2	2	3	1	2	2	2

CONCLUSION

- We proposed a 2.5D cascaded CNN and LSTM network with 3D anchors for mitotic cell detection in 4D microscopic images.
- Our experimental results show that the proposed method can perform better than the state-of-the-art methods such as Faster RCNN, Single Shot Multi-Box Detector (SSD), Hierarchical Convolution Neural Network (HCNN), Two-Stream Bidirectional Long Short-Term Memory (TS-BLSTM), and the winner of the TC-IAIP AIA2017 contest