

# Today: Outline

- **Logistics**
- **Model Selection and Evaluation**
- **Explainable AI**
- **Reminders:**
  - Problem Set 1, due: Oct 12 by midnight
  - Midterm Exam, in class, Oct 20 (Practice problems will be posted)
- **Announcements:**
  - Lab on Fri Oct 9 will be a chance to get help with PS1
  - No class on Oct 13 per BU Calendar (Substitute Mon Schedule of Classes)

# Piazza – Posts

The screenshot displays the Piazza interface for a course (CS 440). The top navigation bar includes tabs for Q & A, Resources, Statistics, and Manage Class. The Resources tab is highlighted with a red circle and an arrow. Below the navigation bar, there's a search bar and a 'New Post' button. The main content area shows a list of posts under the 'Pinned' section. One post, titled 'Problem Set 1 has been added to class resources page under Homework', is highlighted in yellow. The right sidebar shows the details of this post, including its title, description, due date, and a section for followup discussions.

**Problem Set 1 has been added to class resources page under Homework**

The teaching staff has posted a new Homework resource.

Title: Problem Set 1  
[http://www.piazza.com/class\\_profile/get\\_resource/ke1j88mrufa3hz/kfo2mu66sxx542](http://www.piazza.com/class_profile/get_resource/ke1j88mrufa3hz/kfo2mu66sxx542)

Due date: Oct 12, 2020

You can view it on the course page:  
<https://piazza.com/bu/fall2020/cs440/resources>

#pin

hw1

edit · good note 0 Updated 6 days ago by Sarah Adel Bargal

**followup discussions** for lingering questions and comments

**Start a new followup discussion**

Compose a new followup discussion

Average Response Time: 42 min Special Mentions: WANG KAIHONG ans... Online Now: 11 This Week: 100

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# Piazza - Resources

piazza

CS 440 Q & A **Resources** Statistics Manage Class

Boston University - Fall 2020

## CS 440: Artificial Intelligence

+ Add Syllabus

Course Information Staff **Resources**

Edit Resource Sections

### Homework

Manually sort using Sort on: - -

Homework	Due Date	Actions
Problem Set 1	Oct 12, 2020	<a href="#">Edit</a> <a href="#">Post a note</a> <a href="#">Update file</a> <a href="#">Delete</a>

[Add Links](#) [Add Files](#)

### Homework Solutions

Manually sort using Sort on: - -

Nothing has been added to the Homework Solutions section, yet.  
Click the "Add Links" or "Add Files" button to add resources.


[Add Links](#) [Add Files](#)

### Pre-lecture Material

Manually sort using Sort on: - -


Pre-lecture Material	Date	Actions
IBM's Watson Generating a Movie Trailer	Oct 1, 2020	<a href="#">Edit</a> <a href="#">Post a note</a> <a href="#">Update link</a> <a href="#">Delete</a>
AlexNet	Sep 29, 2020	<a href="#">Edit</a> <a href="#">Post a note</a> <a href="#">Update link</a> <a href="#">Delete</a>
How We're Teaching Computers to Understand Pictures	Sep 17, 2020	<a href="#">Edit</a> <a href="#">Post a note</a> <a href="#">Update link</a> <a href="#">Delete</a>
Humanizing Technology	Sep 10, 2020	<a href="#">Edit</a> <a href="#">Post a note</a> <a href="#">Update link</a> <a href="#">Delete</a>

## Lecture Notes


























☒ Manually sort using 
☐ Sort on: - -

Lecture Notes		Lecture Date	Actions
Lecture 9: Video, Password: ICQ!.X2c	≡	Oct 1, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">🔗 Update link</a> <a href="#">🗑 Delete</a>
Lecture 9: Neural Networks V	≡	Oct 1, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">📁 Update file</a> <a href="#">🗑 Delete</a>
Lecture 8: Video, Password: x!8x+V?\$	≡	Sep 29, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">🔗 Update link</a> <a href="#">🗑 Delete</a>
Lecture 8: Neural Networks IV	≡	Sep 29, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">📁 Update file</a> <a href="#">🗑 Delete</a>
Lecture 7: Video, Password: RhT^+IX0	≡	Sep 24, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">🔗 Update link</a> <a href="#">🗑 Delete</a>
Lecture 7: Neural Networks III	≡	Sep 24, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">📁 Update file</a> <a href="#">🗑 Delete</a>
Lecture 6: Video, Password: 7!VG.88g	≡	Sep 22, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">🔗 Update link</a> <a href="#">🗑 Delete</a>
Lecture 6: Neural Networks II	≡	Sep 22, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">📁 Update file</a> <a href="#">🗑 Delete</a>
Lecture 5: Video, Password: DyA&1MTF	≡	Sep 17, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">🔗 Update link</a> <a href="#">🗑 Delete</a>
Lecture 5: Neural Networks I	≡	Sep 17, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">📁 Update file</a> <a href="#">🗑 Delete</a>
Lecture 4: Video, Password: N7fSvw8!	≡	Sep 15, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">🔗 Update link</a> <a href="#">🗑 Delete</a>
Lecture 4: Learning from Examples II	≡	Sep 15, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">📁 Update file</a> <a href="#">🗑 Delete</a>
Lecture 3: Video, Password: ctq\$1ShM	≡	Sep 10, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">🔗 Update link</a> <a href="#">🗑 Delete</a>
Lecture 3: Learning from Examples I	≡	Sep 10, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">📁 Update file</a> <a href="#">🗑 Delete</a>
Lecture 2: Video, Password: 44Wq9Z8&	≡	Sep 8, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">🔗 Update link</a> <a href="#">🗑 Delete</a>
Lecture 2: Ethics in AI	≡	Sep 8, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">📁 Update file</a> <a href="#">🗑 Delete</a>
Lecture 1: Video, Password: j=5HJCF!	≡	Sep 3, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">🔗 Update link</a> <a href="#">🗑 Delete</a>
Lecture 1: Logistics and Intro	≡	Sep 3, 2020	<a href="#">✍ Edit</a> <a href="#">📄 Post a note</a> <a href="#">📁 Update file</a> <a href="#">🗑 Delete</a>

## General Resources

☒ Manually sort using 


☐ Sort on:

General Resources		Actions
Demo: Creating a pdf of an ipynb and submitting on Gradescope		 Edit  Post a note  Update file  Delete
Review: Probability Theory		 Edit  Post a note  Update link  Delete
Review: Partial Derivatives (Section 1 and its exercises)		 Edit  Post a note  Update link  Delete
Review: Linear Algebra		 Edit  Post a note  Update file  Delete
Syllabus		 Edit  Post a note  Update file  Delete














































 Add Links


 Add Files


## Lab Sessions

☒ Manually sort using 

☐ Sort on:

Lab Sessions		Date	Actions
Lab 3: Video, Password: dP^tFP2&		Oct 2, 2020	 Edit  Post a note  Update link  Delete
Lab 3: Tensorflow introduction code		Oct 2, 2020	 Edit  Post a note  Update file  Delete
Lab 3: Tensorflow introduction		Oct 2, 2020	 Edit  Post a note  Update file  Delete
Lab 2: Video, Password: 9jNvgU+q		Sep 25, 2020	 Edit  Post a note  Update link  Delete
Lab 2: Numpy tutorial		Sep 25, 2020	 Edit  Post a note  Update file  Delete
Lab 2: Numpy tutorial code		Sep 25, 2020	 Edit  Post a note  Update file  Delete
Lab 1: Notes		Sep 18, 2020	 Edit  Post a note  Update file  Delete
Lab 1: Video, Password: \$!d9+3^x		Sep 18, 2020	 Edit  Post a note  Update link  Delete
Lab 1: Preliminaries		Sep 18, 2020	 Edit  Post a note  Update file  Delete

 Add Links

 Add Files

# Video Demo

- Installing Tensorflow
- Converting ipynb to pdf
- Submitting pdf on gradescope

<https://www.youtube.com/watch?v=gxR012ZAR4o>

# Gradescope

- Please join the Gradescope with your BU email

<https://www.gradescope.com/courses/186182%E2%80%A9Entry>

- Entry Code: 95Y7JG



## Your Courses

Welcome to Gradescope! Click on one of your courses to the right, or on the Account menu below.

## Your Courses

Fall 2020

**CS 440**

Introduction to Artificial Intelligence

1 assignment

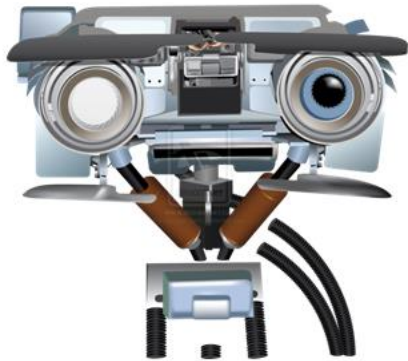
# Dry Run

- Create a pdf from the current notebook with no solutions
- Submit it now in gradescope as a dry run
- Do not wait until you have completed solving the assignment to try out the submission system
- This will give you ample time to ask any questions you have about the submission process before the deadline and will make your future submissions smooth



# Important!

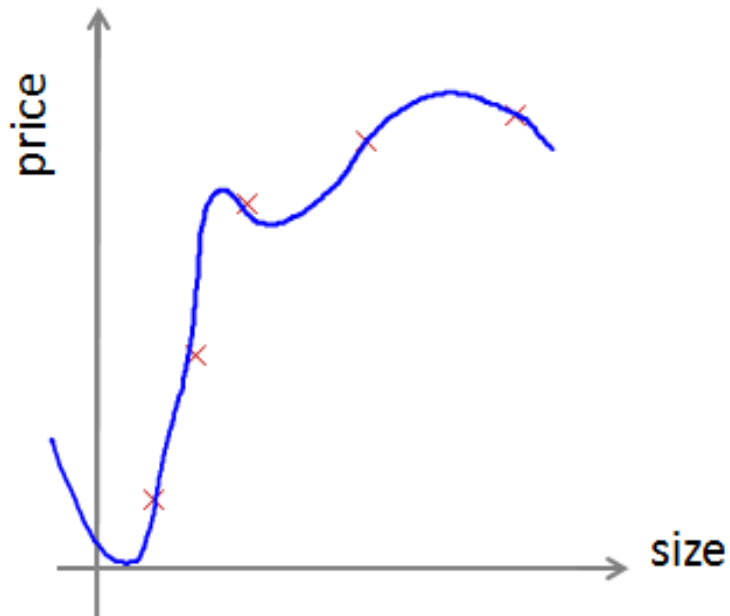
- ***Keep a copy of your ipynb with unchanged last date of modification***
  - Graders might need it, and would be requesting it by email cc ing me
- **Friday's Lab:**  
brief demo + office hour for help with PS1
- We encourage you to make best use of Piazza and Office Hours



# Model Selection

## Training/Validation/Test Sets

# Overfitting example



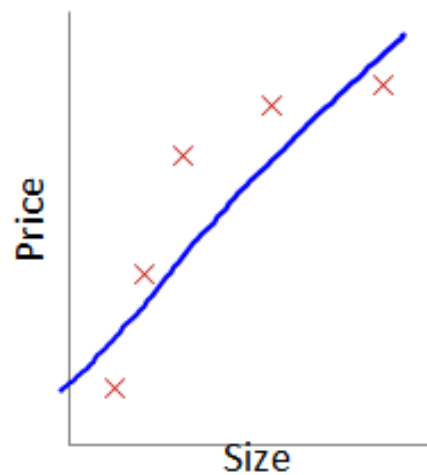
$$h_{\theta}(x) = \theta_0 + \theta_1 x + \theta_2 x^2 + \theta_3 x^3 + \theta_4 x^4$$

Once parameters  $(\theta_0, \theta_1, \dots, \theta_4)$  were fit to some set of data (training set), the error of the parameters as measured on that data (the training error  $J(\theta)$ ) is likely to be lower than the actual generalization error.

One solution is to regularize, but how can we choose the regularization weight  $\lambda$ ?

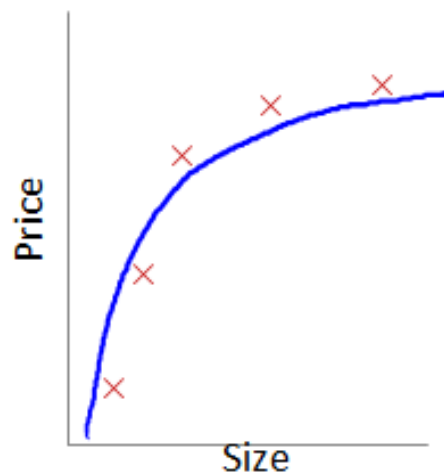
# Choosing weight $\lambda$

$$\theta_0 + \theta_1 x + \theta_2 x^2 + \theta_3 x^3 + \theta_4 x^4$$



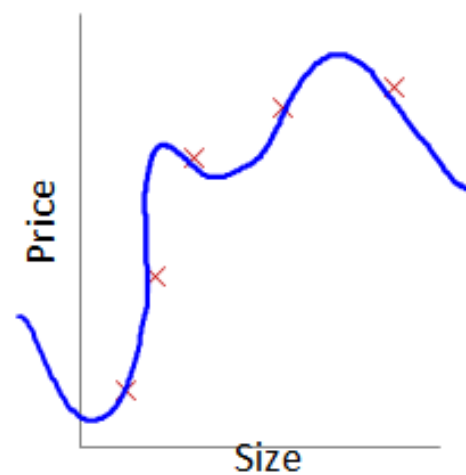
$$\lambda = 100$$

High bias  
(underfit)



$$\lambda = 1$$

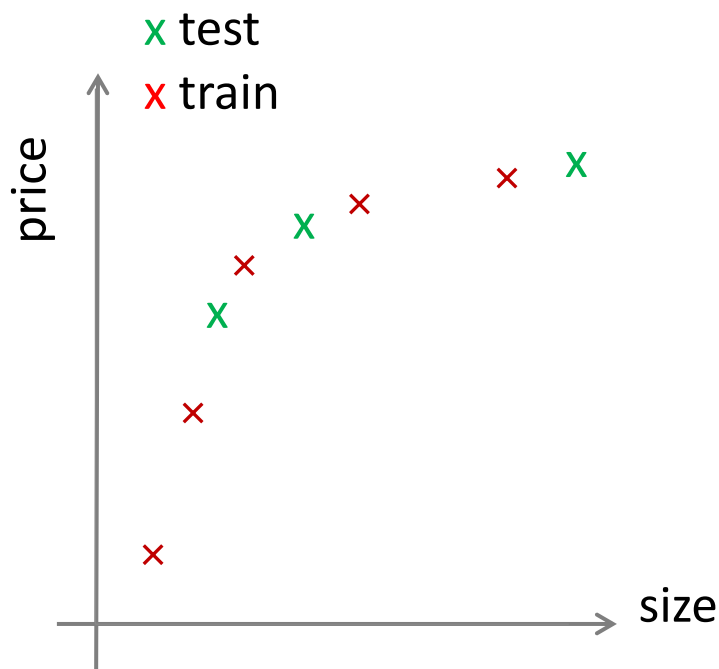
"Just right"



$$\lambda = 0.01$$

High variance  
(overfit)

# Model selection



$$h_{\theta}(x) = \theta_0 + \theta_1 x + \theta_2 x^2 + \theta_3 x^3 + \theta_4 x^4$$

Hyperparameters (e.g., degree of polynomial, regularization weight, learning rate) must be selected prior to training.

How to choose them?

Try several values, choose one with the lowest test error?

Problem: test error is likely an overly optimistic estimate of generalization error because we “cheat” by fitting the hyperparameter to the actual test examples.

# Train/Validation/Test Sets

	Size	Price
train	2104	400
	1600	330
	2400	369
	1416	232
	3000	540
validation	1985	300
	1534	315
	1427	199
test	1380	212
	1494	243

Solution: split data into three sets.

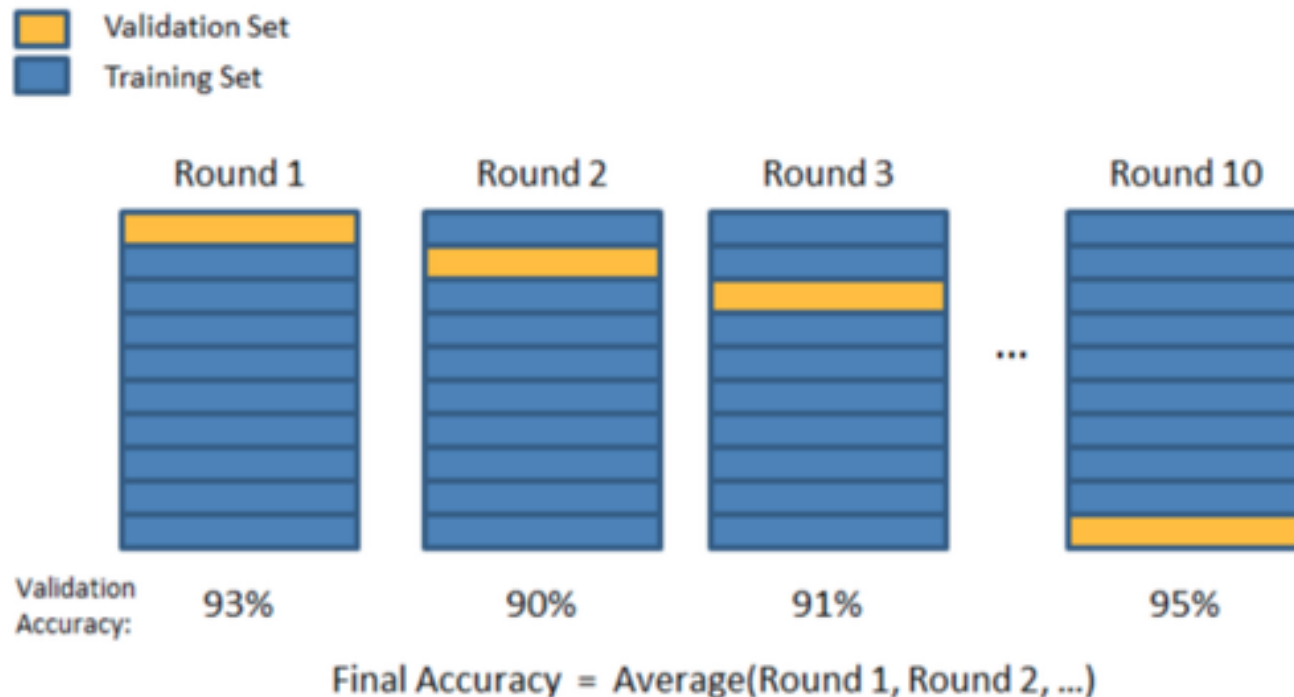
For each value of a hyperparameter, train on the train set, evaluate learned parameters on the validation set.

Pick the model with the hyperparameter that achieved the lowest validation error.

Report this model's test set error.

# N-Fold Cross Validation

- What if we don't have enough data for train/test/validation sets?
- Solution: use N-fold cross validation.
- Split training set into train/validation sets N times.
- Report average predictions over N val sets, e.g. N=10:



# Confusion Matrix

- A performance measurement for machine learning classification problem where output can be two or more classes.

- **True Positive:**  
*predicted positive and it's true*

**True Negative:**  
*predicted negative and it's true*

**False Positive:**  
*predicted positive and it's false*

**False Negative:**  
*predicted negative and it's false*

		Actual Values	
		Positive (1)	Negative (0)
Predicted Values	Positive (1)	TP	FP
	Negative (0)	FN	TN



# Recall

- Out of all the positive classes, how much we predicted correctly. It should be high as possible.

$$\text{Recall} = \frac{TP}{TP + FN}$$

		Actual Values	
		Positive (1)	Negative (0)
Predicted Values	Positive (1)	TP	FP
	Negative (0)	FN	TN

# Precision

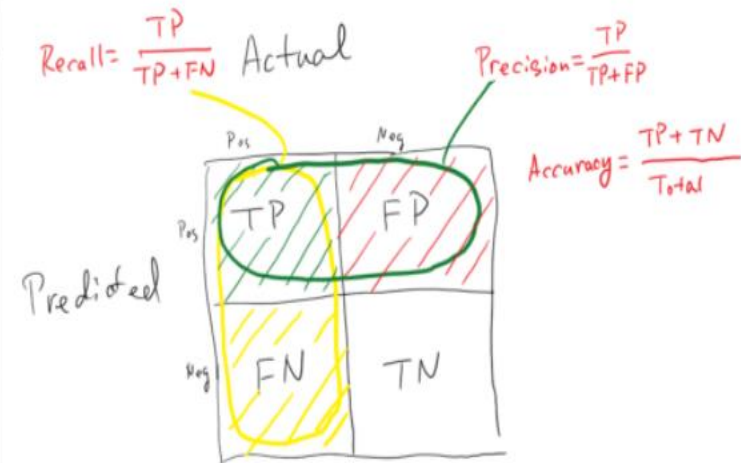
- Out of all the positive classes we have predicted, how many are actually positive.

$$\text{Precision} = \frac{TP}{TP + FP}$$

		Actual Values	
		Positive (1)	Negative (0)
Predicted Values	Positive (1)	TP	FP
	Negative (0)	FN	TN

# Example

y	y pred	output for threshold 0.6	Recall	Precision	Accuracy
0	0.5	0	<b>1/2</b>	<b>2/3</b>	<b>4/7</b>
1	0.9	1			
0	0.7	1			
1	0.7	1			
1	0.3	0			
0	0.4	0			
1	0.5	0			



# F-measure

- F-score helps to measure Recall and Precision at the same time.

$$\mathbf{\textit{F - measure}} = \frac{2 * \text{Recall} * \text{Precision}}{\text{Recall} + \text{Precision}}$$



# Neural Networks VI

Explainability



# Importance of *Explainability*

- An important action to be detected in the vision systems of autonomous vehicles is: *Pedestrian Crossing*



# Importance of *Explainability*

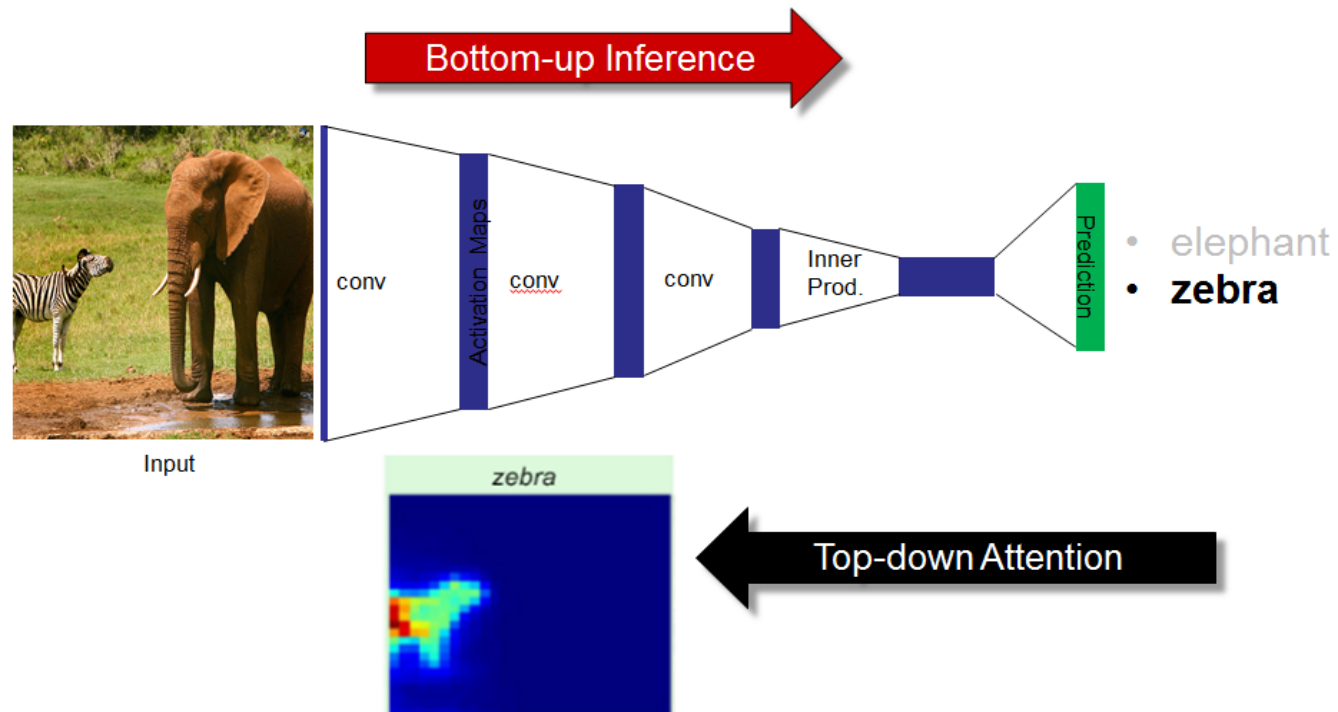
Sample Misclassification



**Ground Truth:**  
*BabyCrawling*

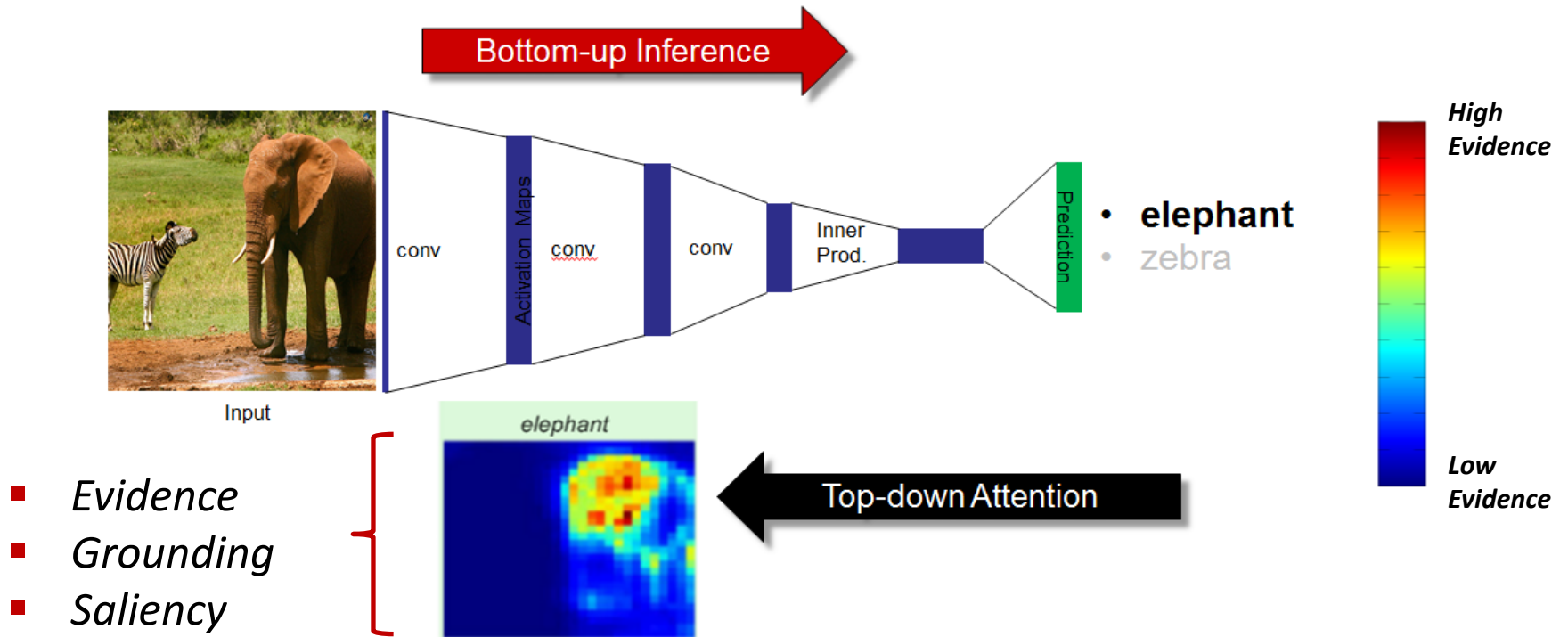
**Classified as:**  
*Pushups*

# Spatial Grounding

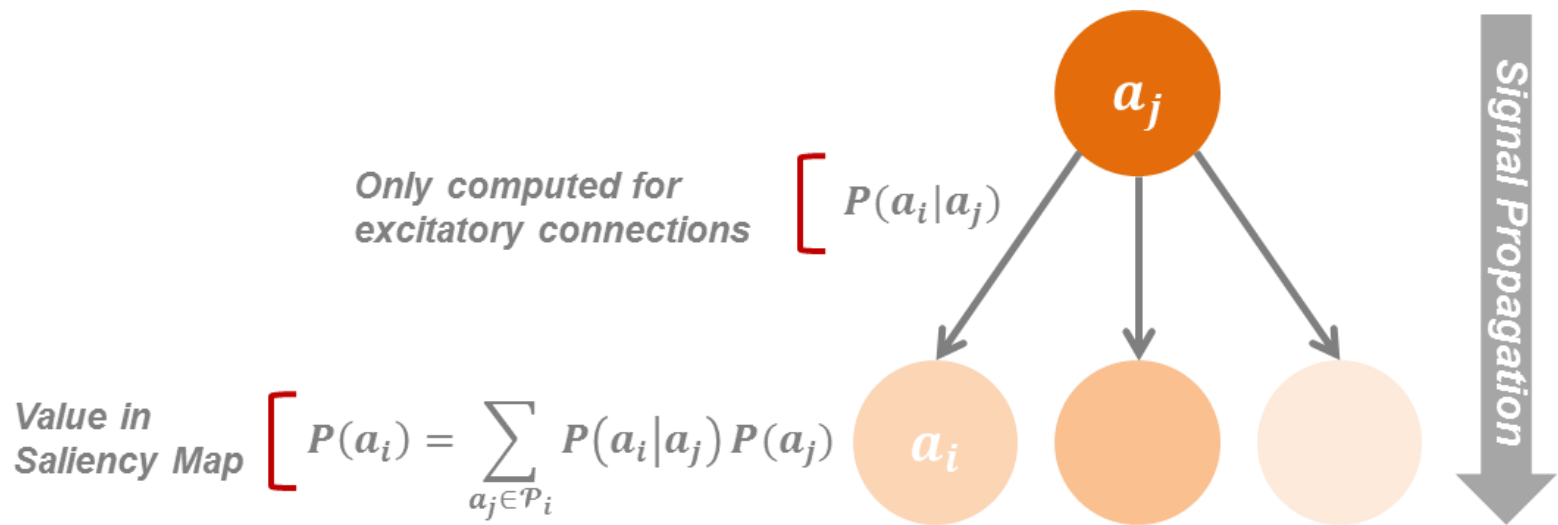




# Spatial Grounding



# Excitation Backprop (EB)



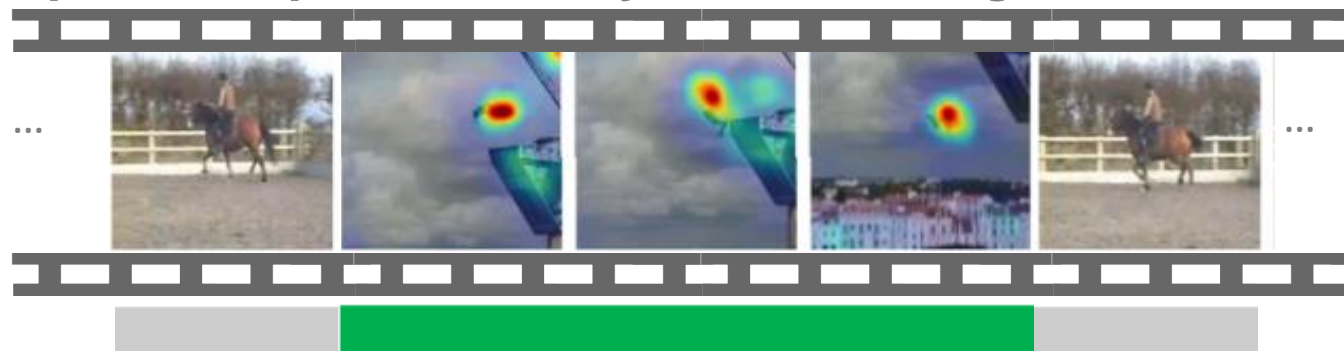
[Jianming Zhang, Zhe Lin, Jonathan Brandt, Xiaohui Shen, Stan Sclaroff. "Top-down Neural Attention by Excitation Backprop., ECCV'16]

# Spatiotemporal Grounding

Input Video Sequence

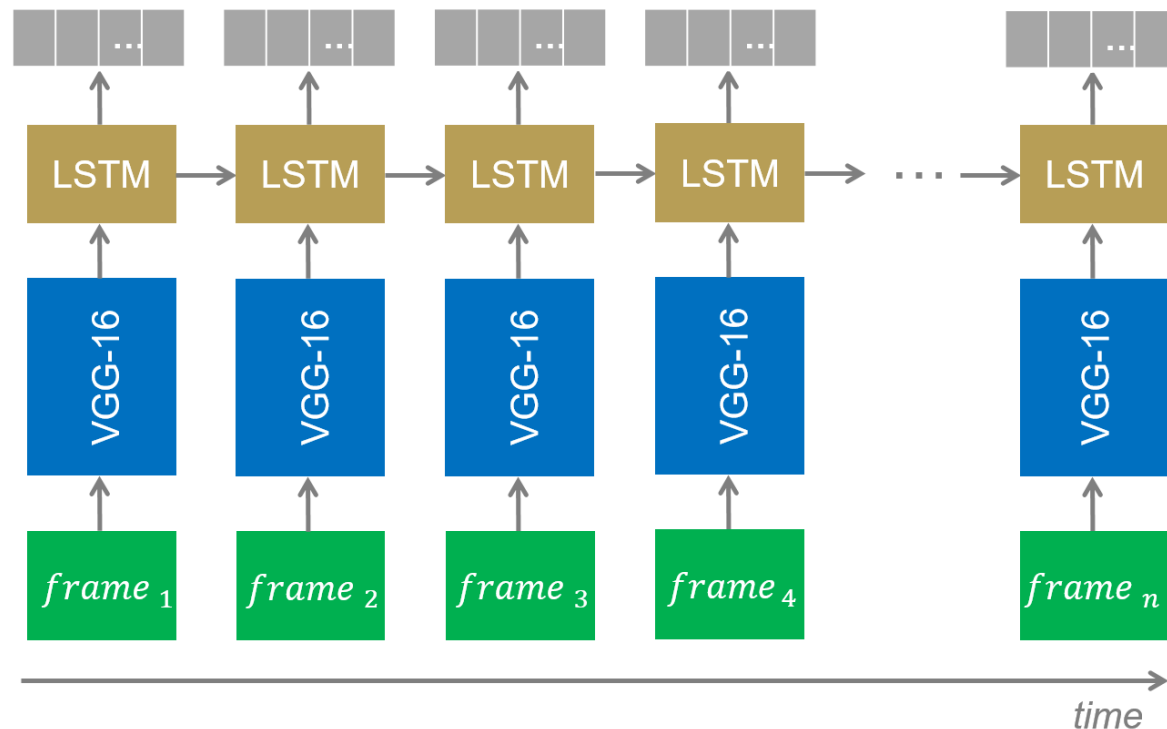


Spatio-temporal Saliency for *CliffDiving*

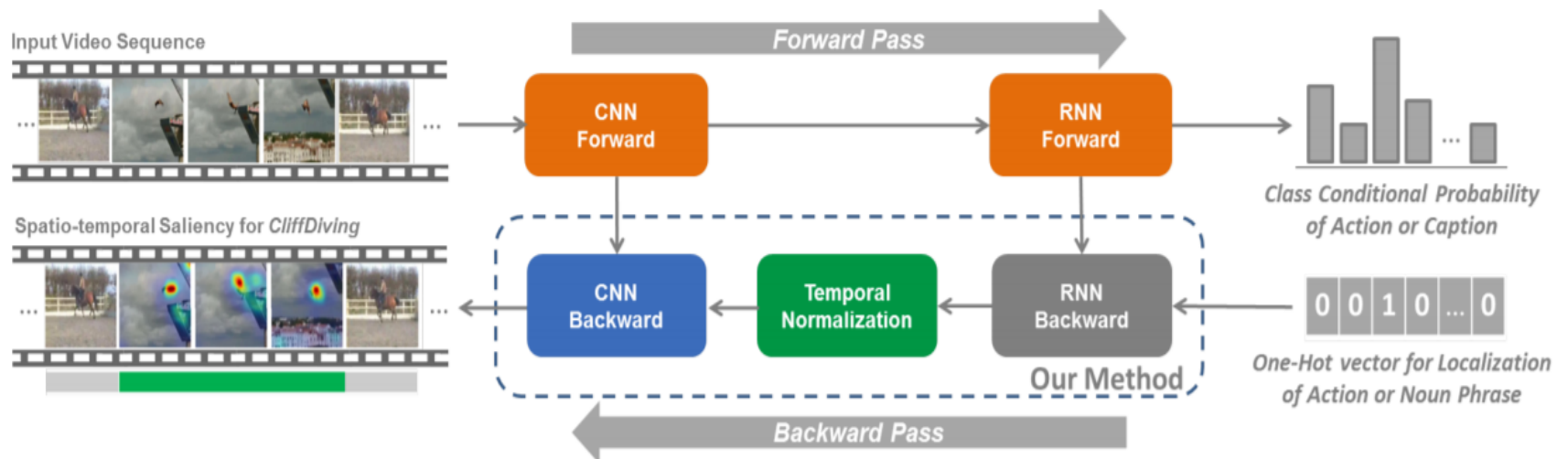


# Architecture: Forward Pass

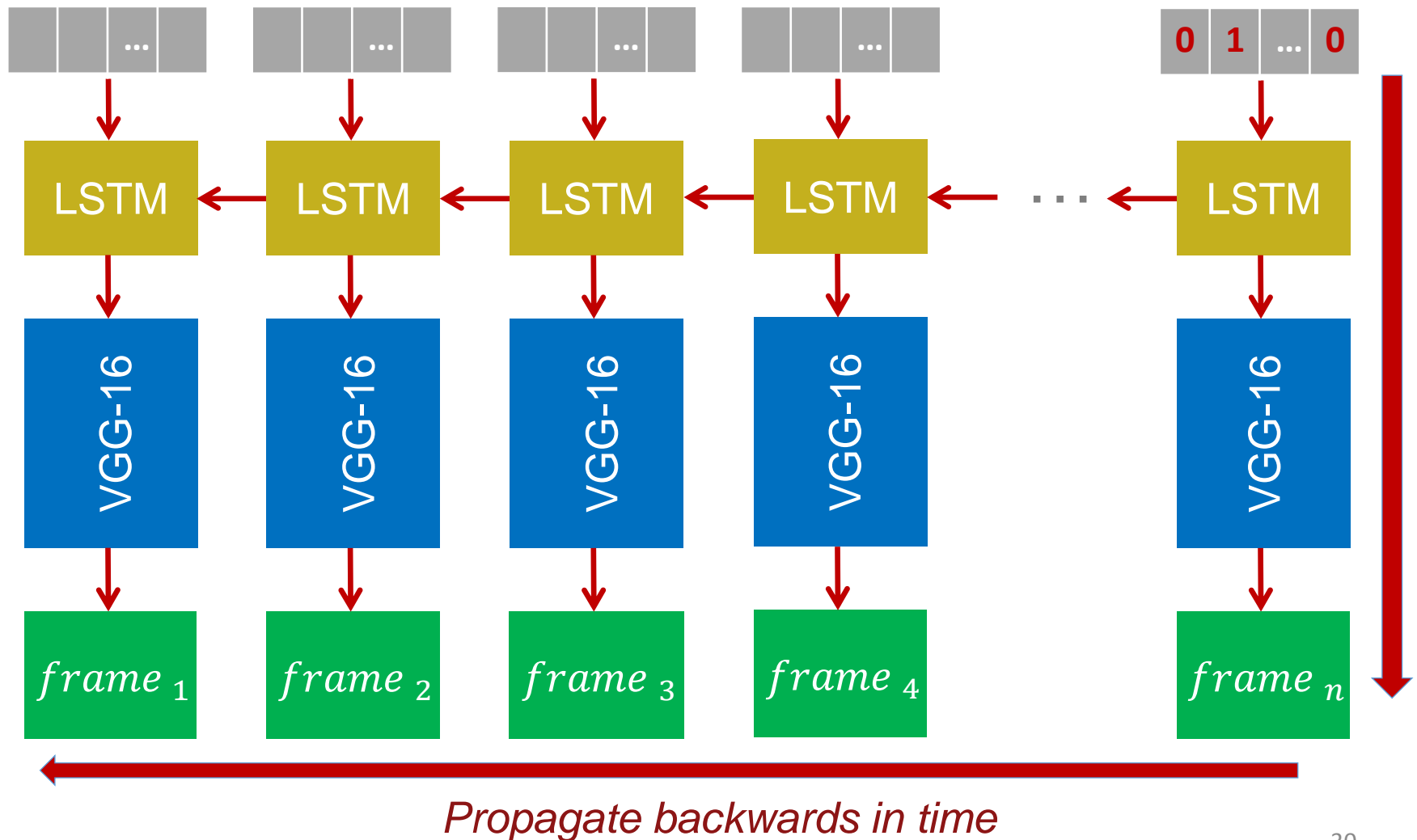
- CNN-LSTM is trained for the action recognition task.
- Resulting grounding is weakly-supervised.



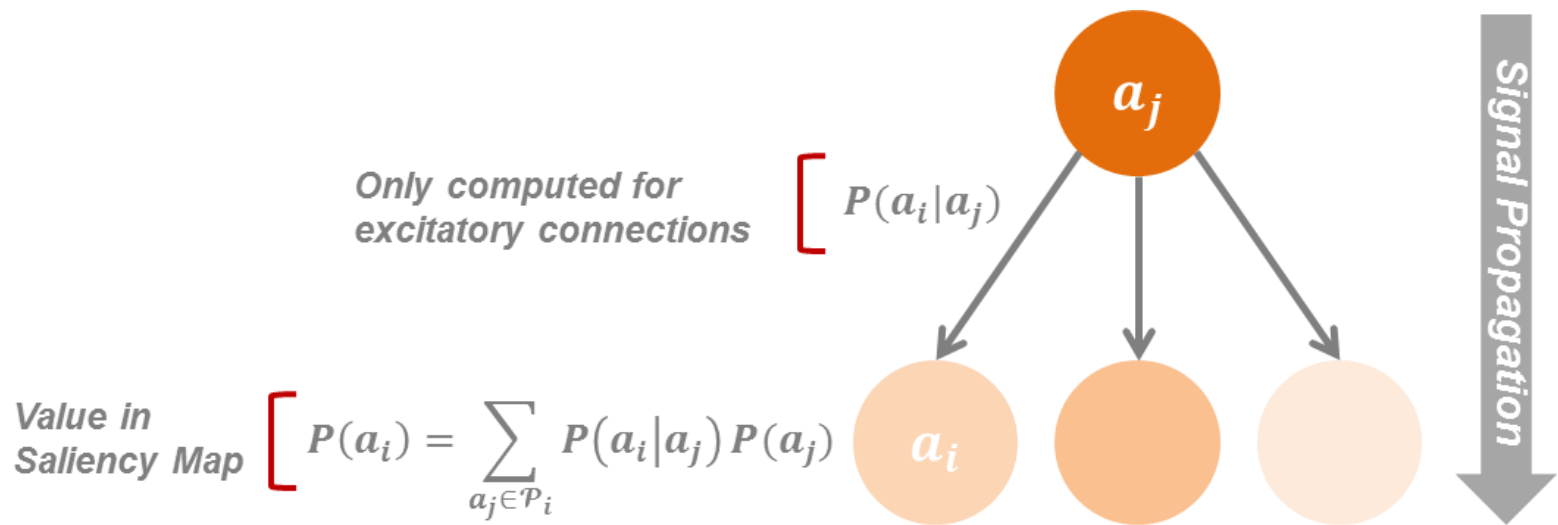
# Excitation Backprop in RNNs



# Architecture: Backward Grounding Pass



# Excitation Backprop (EB)



[Jianming Zhang, Zhe Lin, Jonathan Brandt, Xiaohui Shen, Stan Sclaroff. "Top-down Neural Attention by Excitation Backprop., ECCV'16]

# Applications

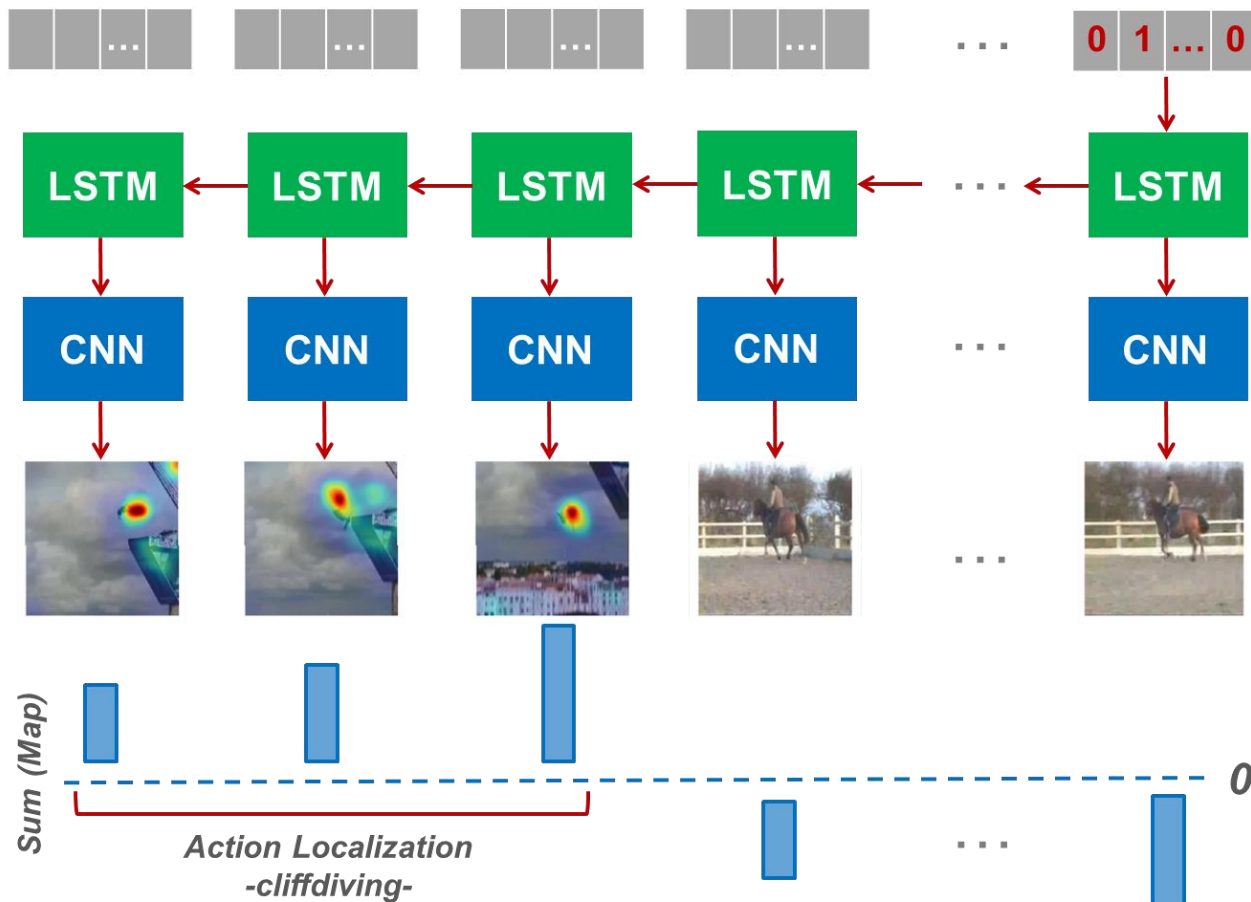
- Action Detection (*videos*)
- Caption Grounding (*images, videos*)
- Reflecting the Abstraction Capability of Models



# Applications

- Action Detection (*videos*)
- Caption Grounding (*images, videos*)
- Reflecting the Abstraction Capability of Models

# Spatiotemporal Action Detection



# Applications

- Action Detection (*videos*)
- Caption Grounding (*images, videos*)
- Reflecting the Abstraction Capability of Models

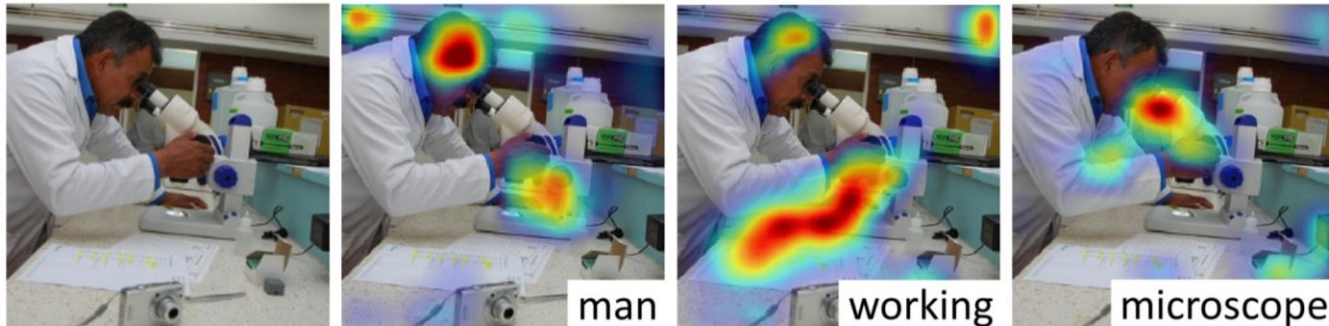
# Flicker30kEntities Dataset: Grounding Words of an Image Caption

image caption: *A man in a lab coat is working on a microscope.*



# Flicker30kEntities Dataset: Grounding Words of an Image Caption

image caption: *A man in a lab coat is working on a microscope.*



# MSRVTT Dataset: Grounding Words of a Video Caption

video caption: *“A man is talking about a phone”*



(a) grounding of the word *man*



(b) grounding of the word *phone*

# Applications

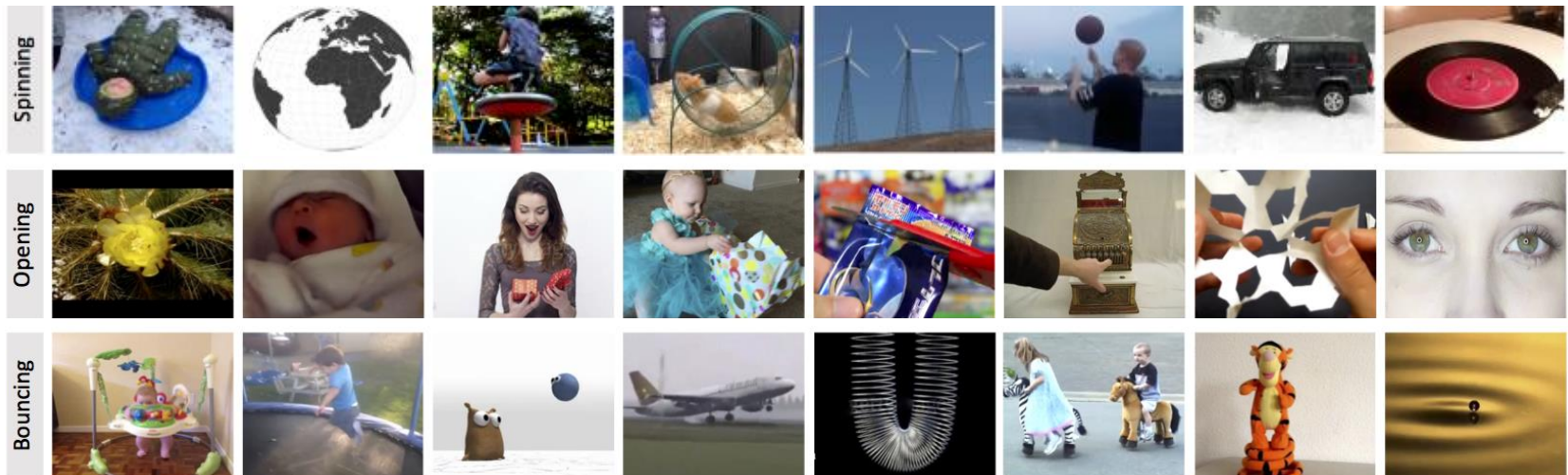
- Action Detection (*videos*)
- Caption Grounding (*images, videos*)
- Reflecting the Abstraction Capability of Models

# Reflecting the Abstraction Capability of Models

- Moments in Time Dataset

M. Monfort, A. Andonian, B. Zhou, K. Ramakrishnan, S. A. Bargal, T. Yan, L. Brown, Q. Fan, D. Gutfrund, C. Vondrick, A. Oliva. "Moments in Time Dataset: one million videos for event understanding." *TPAMI*, 2019.

- Videos of abstract dynamical events performed by various actors.





# Moments in Time Dataset

- Typically, classification accuracy is reported to summarize the recognition capability of models.
- However, classification accuracy alone is not representative as to whether the models are really modeling this diversity of actors.
- A classifier may be incorrectly classifying a whole subset of cases/actors.

# Moments in Time Dataset

- Class: *Opening*

