On the Effectiveness of Crowd Sourcing Avian Nesting Video Analysis at Wildlife@Home

Travis Desell, Kyle Goehner

Department of Computer Science
University of North Dakota

Alicia Andes, Rebecca Eckroad, Susan Ellis-Felege

Department of Biology
University of North Dakota

http://csgrid.org/csg/wildlife

June 3, 2015 ICCS 2015 - Reykjavik, Iceland

What is Wildlife@Home?

- A *citizen science* project that combines both crowd sourcing and volunteer computing.
- Users volunteer their brain power by observing videos and reporting observations.
- Users volunteer their computer power by downloading videos and running various computer vision algorithms.
- A scientific web portal to robustly analyze and compare results from users, experts and the computer vision techniques.

Sharp-tailed Grouse

Interior Least Tern

Piping Plover

Between 2012 and now, Dr. Ellis-Felege has gathered around 100,000 hours of avian nesting video from the following species:

1. Sharp-tailed grouse (*Tympanuchus phasianellus*), an important game bird and wildlife health indicator species.
2. Piping plovers (*Charadrius melodus*), a federally listed threatened species.
3. Interior least terns (*Sternula antillarum*), a federally listed endangered species.

More video is incoming (ducks from Ducks Unlimited), and we have recently received over 2 million motion sensor camera images from a new Hudson Bay project.

Sharp-tailed Grouse

Piping Plover

All three current species are ground nesting birds.

Sharp-tailed grouse nest in the dense grass (top left). Nests were monitored in areas of high oil development, moderate oil development and no oil development (protected state land).

Piping plover and interior least tern are shore nesting species (top right). Nests were monitored along the Missouri River in North Dakota.

What's the point?

1. Current cameras that use automated motion detection miss small predators and are not robust enough.
2. Camera footage allows Dr. Ellis-Felege to manage and evaluate studies with large enough sample sizes for statistical significance.
3. Answer biological questions about parental investment and predator-prey interactions for these ground nesting species.
4. Examine the effect of oil development on wildlife in western North Dakota, which is experiencing a boom in fracking.

Most grouse video is sleeping birds and grass blowing in the wind.
But occasionally, interesting things happen.

Piping plover and tern video is more interesting, with active bi-parental involvement and less obscuring vegetation.

There are many challenges:

1. Dramatically changing weather conditions
2. Dawn/Day/Dusk/Night lighting conditions
3. Model species (sharp tailed grouse and piping plover) and some predators have cryptic coloration (camouflage).
4. Moving vegetation and insects can cause false negatives.

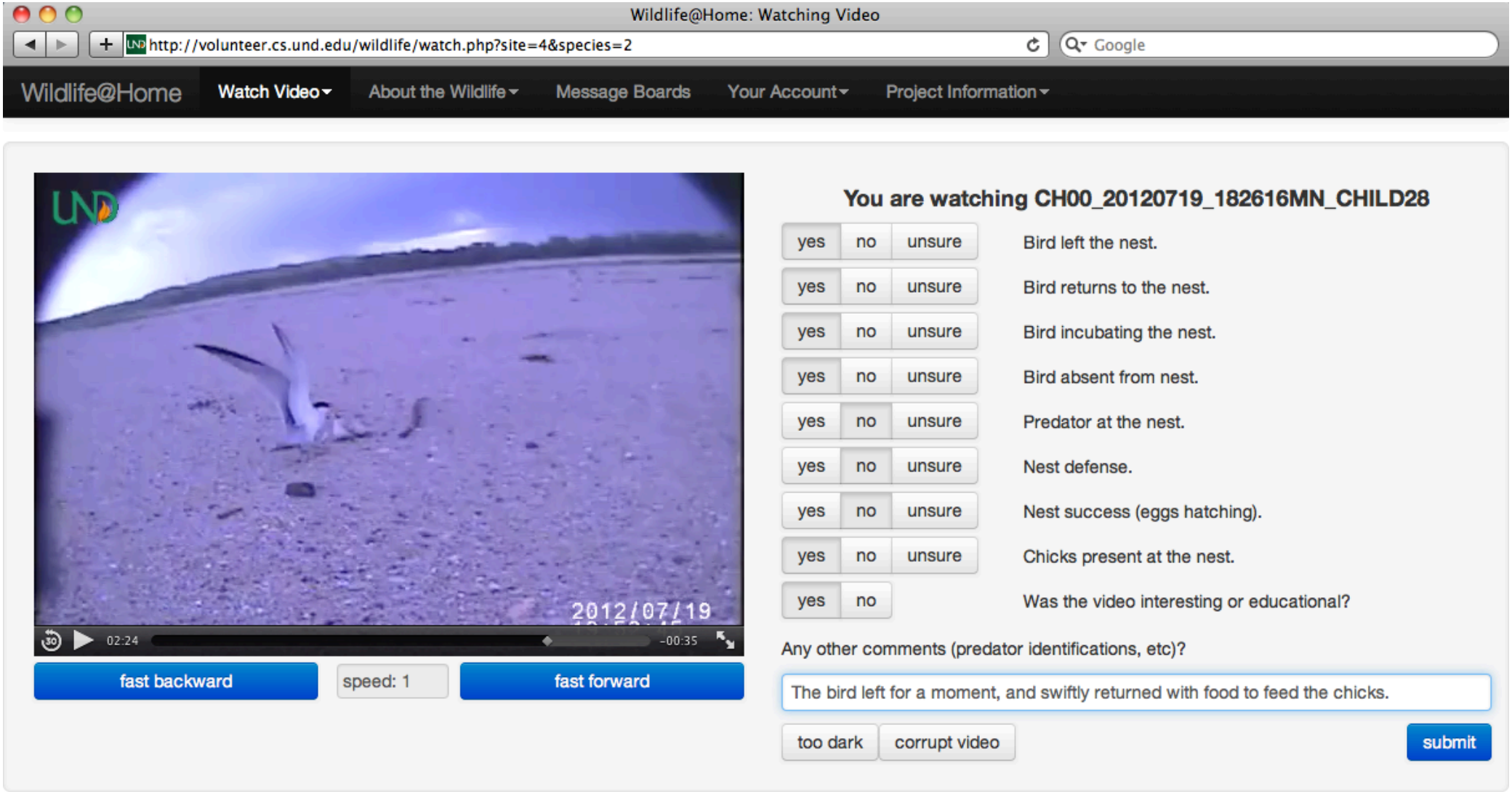
From all this video, we want to determine:

1. Bird Presence
2. Nest Defense
3. Predation Events
4. Nest Success
5. Other events of interest

This work focuses on how we are using crowd sourcing to get an accurate set of training/testing data for the various computer vision techniques we are investigating.

A Tale of Two Interfaces

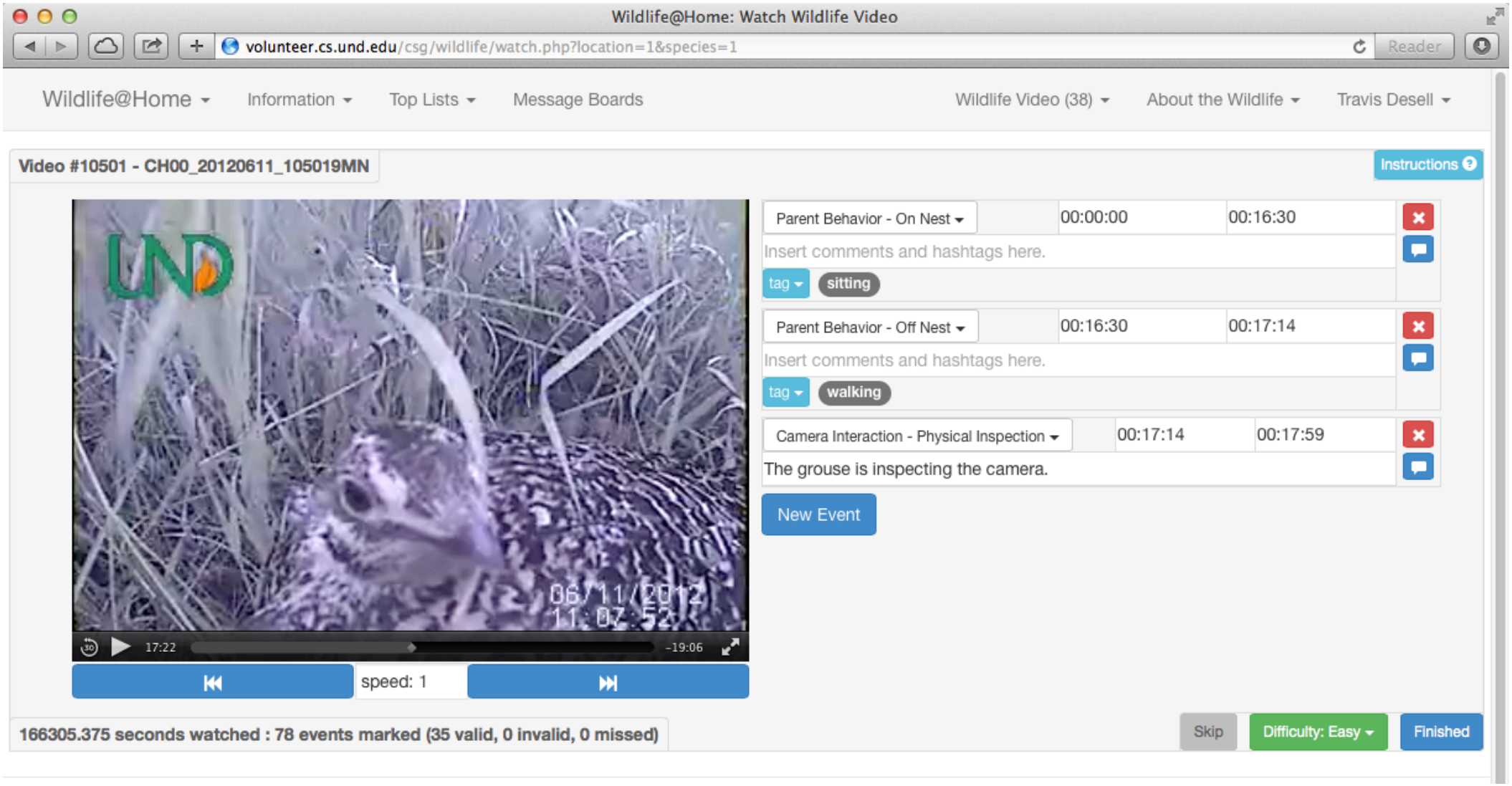
Original Interface



Originally, Wildlife@Home has a simple interface where users could select yes, no or unsure to specify if an event happened at any time during the video.

As we'll see, this simplicity actually had it's costs.

New Interface



The new interface is significantly more complex, but allows for very accurate specification of when events occur and also (almost) identical to what Dr. Ellis-Felege's research assistants use.

Original Interface

Duration (s)	Completed	Observations	Valid	Invalid	Inconvclusive	Valid (%)
< 180	89,645	220,320	206,193	13,129	618	93.58
181 ... 300	8,942	18,715	17,930	649	75	95.80
301 ... 600	6,446	14,022	12,899	1,033	50	91.99
601 ... 1200	3,785	8,396	7,569	744	55	90.15
Total	108,818	261,453	244,591	15,555	798	93.55

Results gathered over 9 months, from August 2013 to April 2014:

- 206 users provided 261,453 observations for 108,818 video segments (~2.4 views to reach a quorum for a video segment)
- 261,453 observations total over 7,411.2 hours of video watched by volunteers. Only 798 were marked inconclusive, and 15,555 marked invalid.
- In the later months of the original interface, video segments were also generated with durations greater than 3 minutes, due to feedback from the users and an interest in seeing how well volunteers would perform on longer video segments. Additional video segments were generated with 5, 10 and 20 minute durations.

Accuracy of Original Interface

Event Type	Total	TP	TN	FP	FN	Accuracy (%)
Bird Leave/Return	12501	154	8504	287	3556	69
Bird Presence	21230	9407	1338	9270	1215	51
Bird Absence	9540	1092	4680	2173	1595	61
Predator Presence	414	4	393	11	6	96
Nest Defense	33	0	33	0	0	100
Chick Presence	708	12	418	252	26	61

Of the 108,818 video segments marked by volunteers, 25,549 corresponded to videos that were marked by the projects experts.

- True positives (TP) were when a quorum of volunteers marked an event as occurring a video segment, and the times of the video segment overlapped with the time of a similar expert event.
- False positives (FP) were when the marked event did not overlap with the time of a similar expert event.
- True negatives (TN) were when the event was not marked and an expert did not mark the event during that time.
- False negatives (FN) were when the event was not marked and an expert did mark an event during that time.

Accuracy of Original Interface

Event Type	Total	TP	TN	FP	FN	Accuracy (%)
Bird Leave/Return	12501	154	8504	287	3556	69
Bird Presence	21230	9407	1338	9270	1215	51
Bird Absence	9540	1092	4680	2173	1595	61
Predator Presence	414	4	393	11	6	96
Nest Defense	33	0	33	0	0	100
Chick Presence	708	12	418	252	26	61

Predator presence and nest defense were very accurate, at 96% and 100%.

Bird Leave/Return were fairly accurate at 69%.

Bird absence was not great at 61%.

Bird presence was especially poor at 51% (essentially random guesses).

There were not enough nest success events for comparison.

New Interface

Results gathered over 9 months, from April 2014 to January 2015:

- 150 users provided 25,427 observations for 8,338 full length videos, with the average video duration being 53 minutes (durations ranged from 1 second to 11 hours)
- This totaled over 21,065 hours of video watched by volunteers.

Accuracy of New Interface

5 second buffer

Event	Misses	Type Mismatch	Matches
Parent Behavior - Not In Video	221 (0.23)	23 (0.02)	708 (0.74)
Chick Behavior - In Video	13 (0.93)	0 (0.00)	1 (0.07)
Territorial - Predator	8 (0.53)	1 (0.07)	6 (0.40)
Territorial - Non-Predator Animal	14 (0.93)	0 (0.00)	1 (0.07)
Camera Interaction - Attack	12 (0.57)	9 (0.43)	0 (0.00)
Camera Interaction - Physical Inspection	22 (0.55)	7 (0.18)	11 (0.28)
Camera Interaction - Observation	9 (0.64)	3 (0.21)	2 (0.14)
Error - Video Error	12 (0.09)	7 (0.05)	120 (0.86)
Error - Camera Issue	12 (0.09)	47 (0.34)	78 (0.57)
Parent Behavior - On Nest	484 (0.11)	152 (0.04)	3686 (0.85)
Parent Behavior - Off Nest	315 (0.31)	16 (0.02)	701 (0.68)

10 second buffer

Event	Misses	Type Mismatch	Matches
Parent Behavior - Not In Video	177 (0.19)	26 (0.03)	749 (0.79)
Chick Behavior - In Video	13 (0.93)	0 (0.00)	1 (0.07)
Territorial - Predator	8 (0.53)	1 (0.07)	6 (0.40)
Territorial - Non-Predator Animal	13 (0.87)	1 (0.07)	1 (0.07)
Camera Interaction - Attack	10 (0.48)	11 (0.52)	0 (0.00)
Camera Interaction - Physical Inspection	12 (0.30)	14 (0.35)	14 (0.35)
Camera Interaction - Observation	7 (0.50)	4 (0.29)	3 (0.21)
Error - Video Error	12 (0.09)	7 (0.05)	120 (0.86)
Error - Camera Issue	12 (0.09)	47 (0.34)	78 (0.57)
Parent Behavior - On Nest	409 (0.09)	168 (0.04)	3745 (0.87)
Parent Behavior - Off Nest	253 (0.25)	29 (0.03)	750 (0.73)

We were able to directly compare user observations from the new interface to the expert observations.

Given a buffer time (events matched if the start and end times were within X seconds of each other), we were able to significantly increase user accuracy.

On nest - 51% to 85-87%

Off nest - 69% to 68-73%

Absence - 61% to 74-79%

Accuracy of New Interface

5 second buffer

Event	Misses	Type Mismatch	Matches
Parent Behavior - Not In Video	221 (0.23)	23 (0.02)	708 (0.74)
Chick Behavior - In Video	13 (0.93)	0 (0.00)	1 (0.07)
Territorial - Predator	8 (0.53)	1 (0.07)	6 (0.40)
Territorial - Non-Predator Animal	14 (0.93)	0 (0.00)	1 (0.07)
Camera Interaction - Attack	12 (0.57)	9 (0.43)	0 (0.00)
Camera Interaction - Physical Inspection	22 (0.55)	7 (0.18)	11 (0.28)
Camera Interaction - Observation	9 (0.64)	3 (0.21)	2 (0.14)
Error - Video Error	12 (0.09)	7 (0.05)	120 (0.86)
Error - Camera Issue	12 (0.09)	47 (0.34)	78 (0.57)
Parent Behavior - On Nest	484 (0.11)	152 (0.04)	3686 (0.85)
Parent Behavior - Off Nest	315 (0.31)	16 (0.02)	701 (0.68)

10 second buffer

Event	Misses	Type Mismatch	Matches
Parent Behavior - Not In Video	177 (0.19)	26 (0.03)	749 (0.79)
Chick Behavior - In Video	13 (0.93)	0 (0.00)	1 (0.07)
Territorial - Predator	8 (0.53)	1 (0.07)	6 (0.40)
Territorial - Non-Predator Animal	13 (0.87)	1 (0.07)	1 (0.07)
Camera Interaction - Attack	10 (0.48)	11 (0.52)	0 (0.00)
Camera Interaction - Physical Inspection	12 (0.30)	14 (0.35)	14 (0.35)
Camera Interaction - Observation	7 (0.50)	4 (0.29)	3 (0.21)
Error - Video Error	12 (0.09)	7 (0.05)	120 (0.86)
Error - Camera Issue	12 (0.09)	47 (0.34)	78 (0.57)
Parent Behavior - On Nest	409 (0.09)	168 (0.04)	3745 (0.87)
Parent Behavior - Off Nest	253 (0.25)	29 (0.03)	750 (0.73)

Also, we feel that the numbers would be even more accurate as a recent survey of users found that 38% do not consider themselves fluent in English - which could hamper their understanding of use instructions for the more complicated new interface.

Difficulty vs. Accuracy

	Easy	Medium	Hard
Misses	2529 (0.15)	145 (0.14)	90 (0.20)
Type Mismatch	1056 (0.06)	57 (0.05)	24 (0.05)
Matches	13774 (0.79)	863 (0.81)	330 (0.74)

We also provided a way for users to specify how challenging it was to mark events in a video.

Interestingly, those with the highest accuracy had medium difficulty (as opposed to easy).

What's Next?

What's Next?

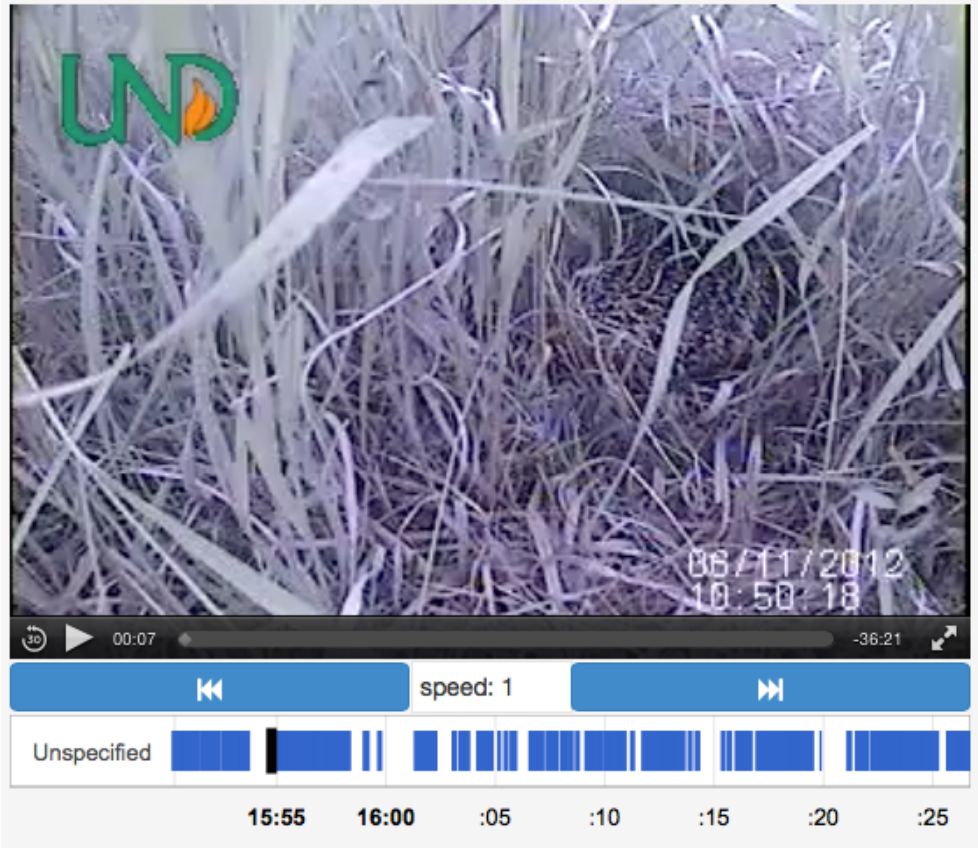
Background Subtractions methods can detect events of interest with fairly high accuracy (apart from some highly windy grouse video):

Kyle Goehner, Rebecca Eckroad, Leila Mohsenian, Paul Burr, Nicholas Caswell, Alicia Andes, Susan Ellis-Felege, and Travis Desell. **A Comparison of Background Subtraction Algorithms for Detecting Avian Nesting Events in Uncontrolled Outdoor Video.** The *11th IEEE International Conference on eScience (eScience 2015)*. Munich, Germany. August 31 - September 4, 2015.

These methods are being integrated into the web interface. Regions in blue on the timeline are periods of activity.

We have also made available our first data release of 200+ videos along with the volunteer and expert observations for reproducibility and use by the computer vision community:

http://csgrid.org/csg/wildlife/data_releases.php



What's Next?

Adding new species (ducks, etc).

Expanding the project to handle images from motion sensing camera traps.

Handling video & imagery from new projects involving UAS surveys.

New computer vision techniques for detection of events in the most challenging video where background subtraction performs poorly, e.g., high winds and rapid light fluctuations from weather.

Now that we can detect many events of interest with background subtraction, can we classify them (i.e., were they from a predator, bird leaving/returning, chicks, etc).

Acknowledgements

Wildlife@Home is currently being supported by NSF award no. 1319700 through the Division of Intelligent Information Systems's Information Integration and Informatics (III) program.

Wildlife@Home has been generously supported by a collaborative research award and new faculty SEED grant from UND's Office of Research Development and Compliance. The project's video streaming server is hosted by UND's Computational Research Center and the volunteer computing server is hosted by UND's Scientific Computing Center. DNA@Home is under partial support from a Basic Sciences SEED Grant.

North Dakota Game and Fish has provided financial support for field logistics to collect sharp-tailed grouse videos.

The US Geological Survey has provided financial support for camera equipment, video storage, and field assistance to collect data for the piping plover and interior least tern.

And of course all our volunteers.

Thanks!

Questions?

Home Page: http://people.cs.und.edu/~tdesell/

Citizen Science Grid: http://csgrid.org

tdesell@cs.und.edu