Aug. 17, 2013, IEEE/NSF Workshop on Cloud Manufacturing and Automation, Madison, WI

Cloud Mediated Nature Observation

- From Teleoperation to Cloud Robotics

Dez Song
Texas A&M University

Smithsonian

Microsoft

Panasonic

Thanks to:

Ni Qin, Yiliang Xu, Wen Li, Chang Young Kim, TAMU
Jingtai Liu, Hongpeng Wang, Nankai U
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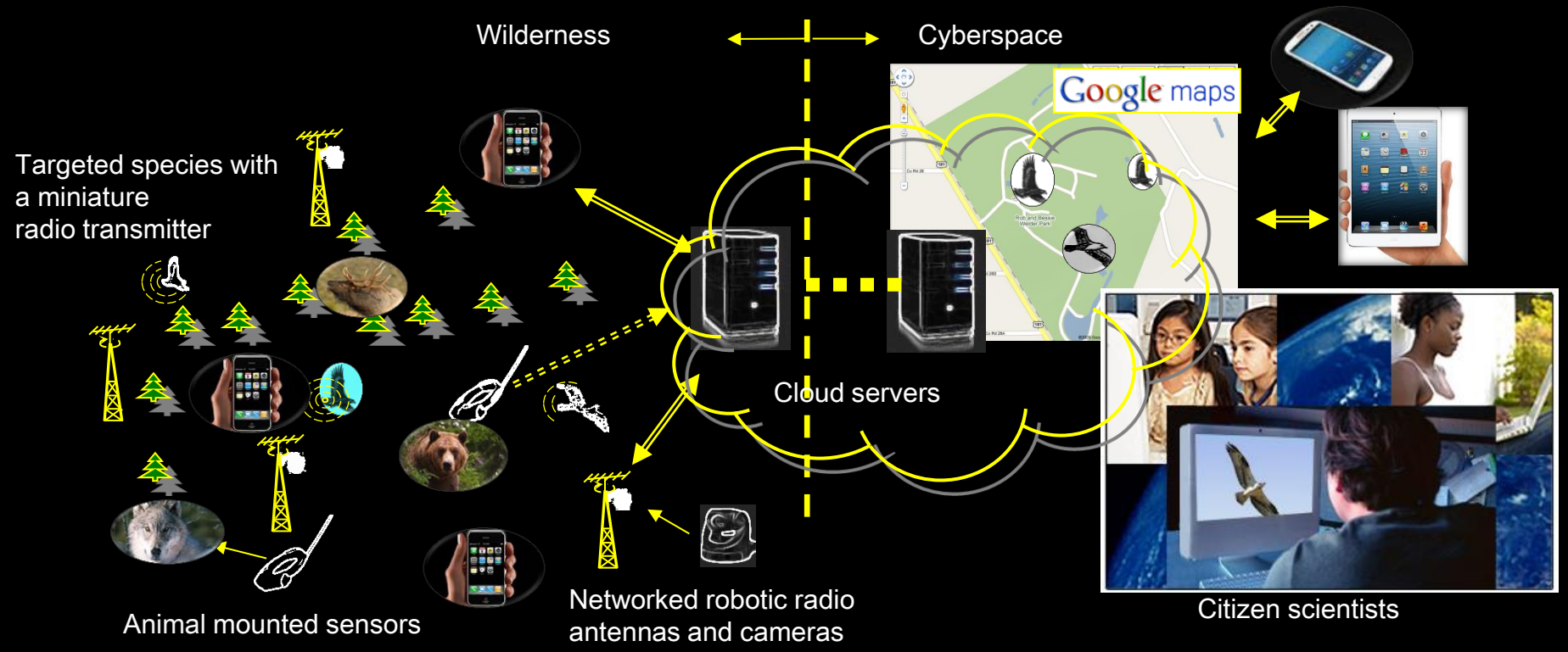
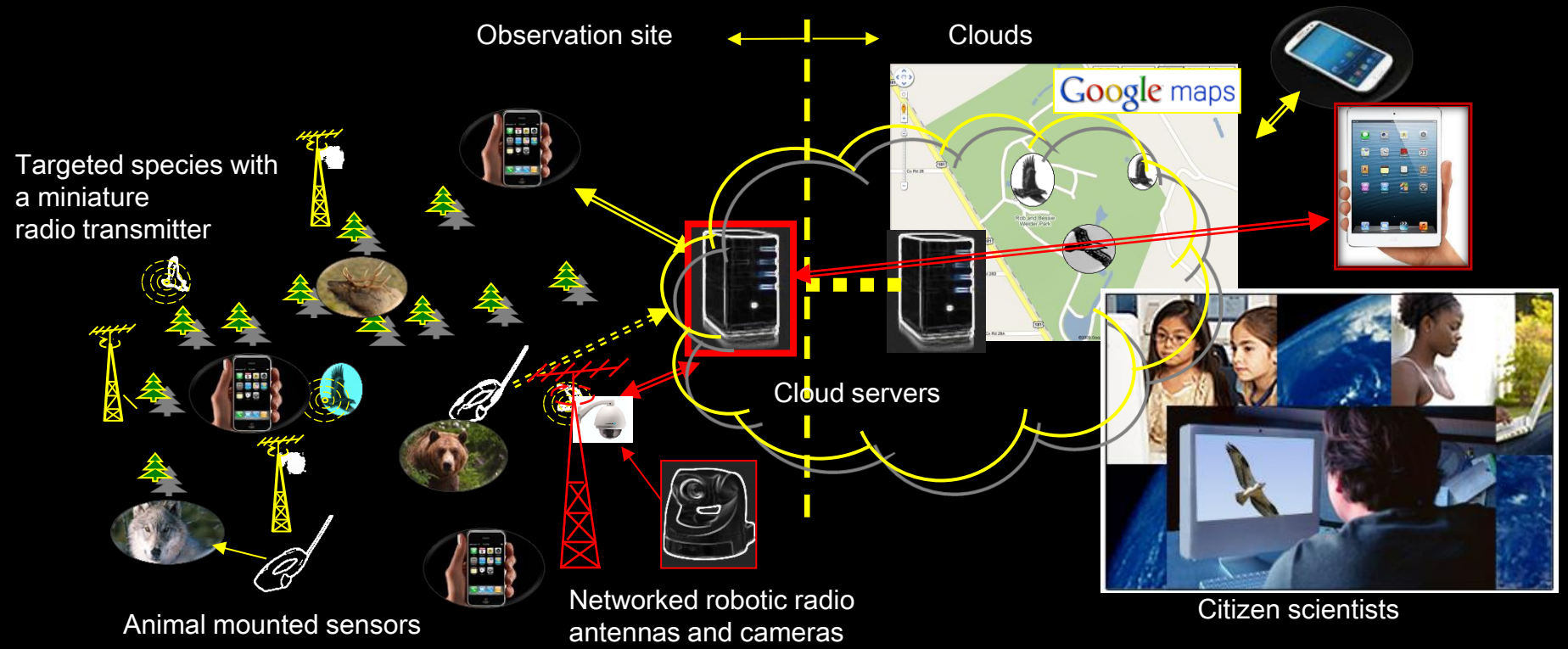
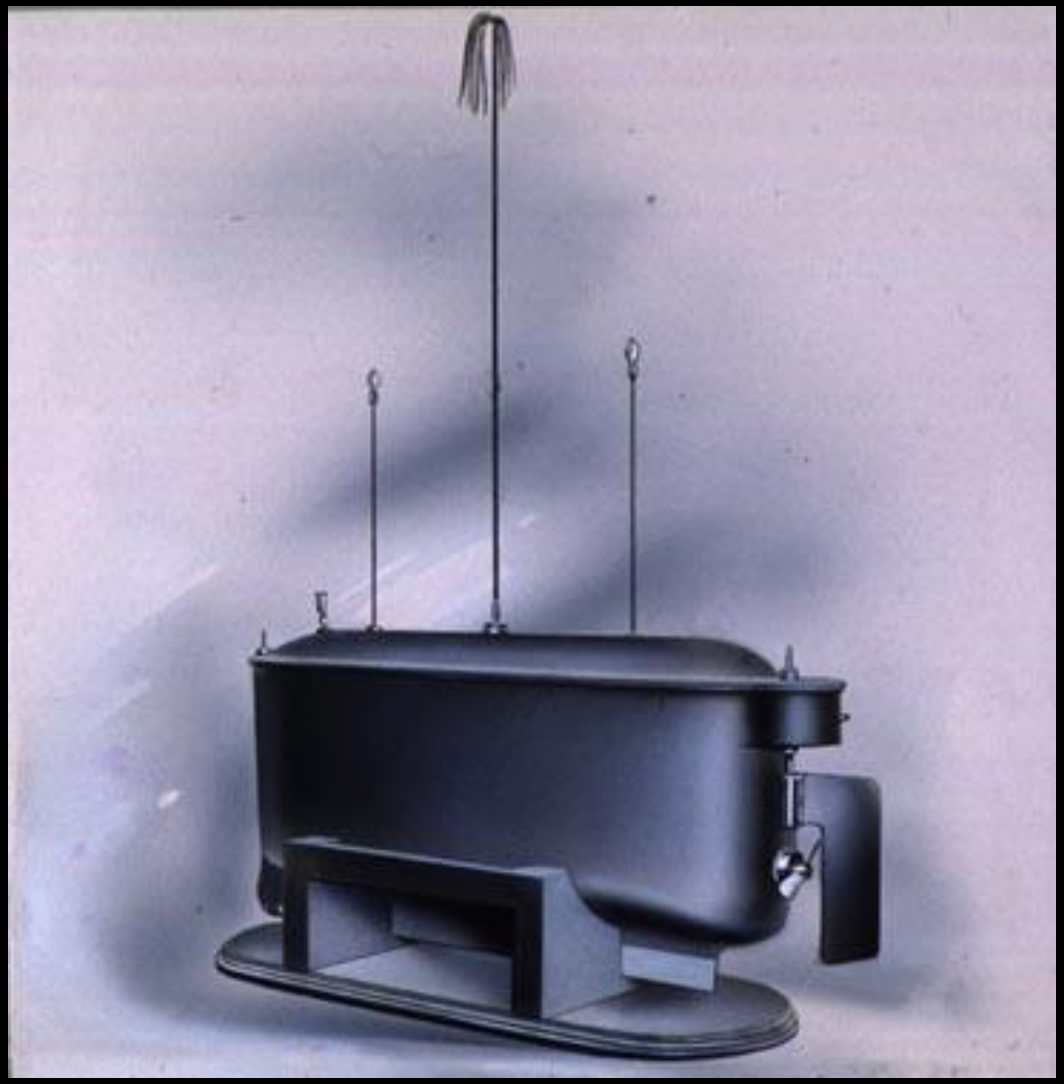
David Luneau, U Arkansas
John Rappole, Smithsonian
Selma Glasscock, Welder Wildlife Foundation
National Science Foundation
The Nature Conservancy
Arkansas Game and Fish Commission
U.S. Fish and Wildlife Service
Arkansas Electric Cooperative
Cache River National Wildlife Refuge

Architecture



Teleoperation

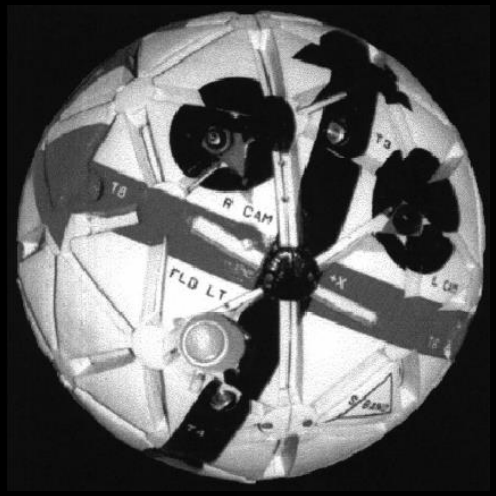


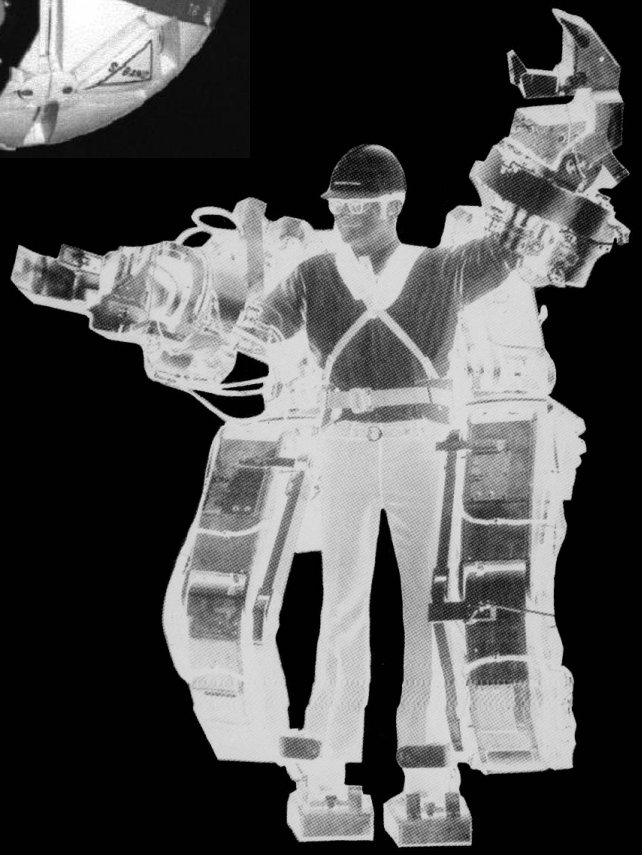


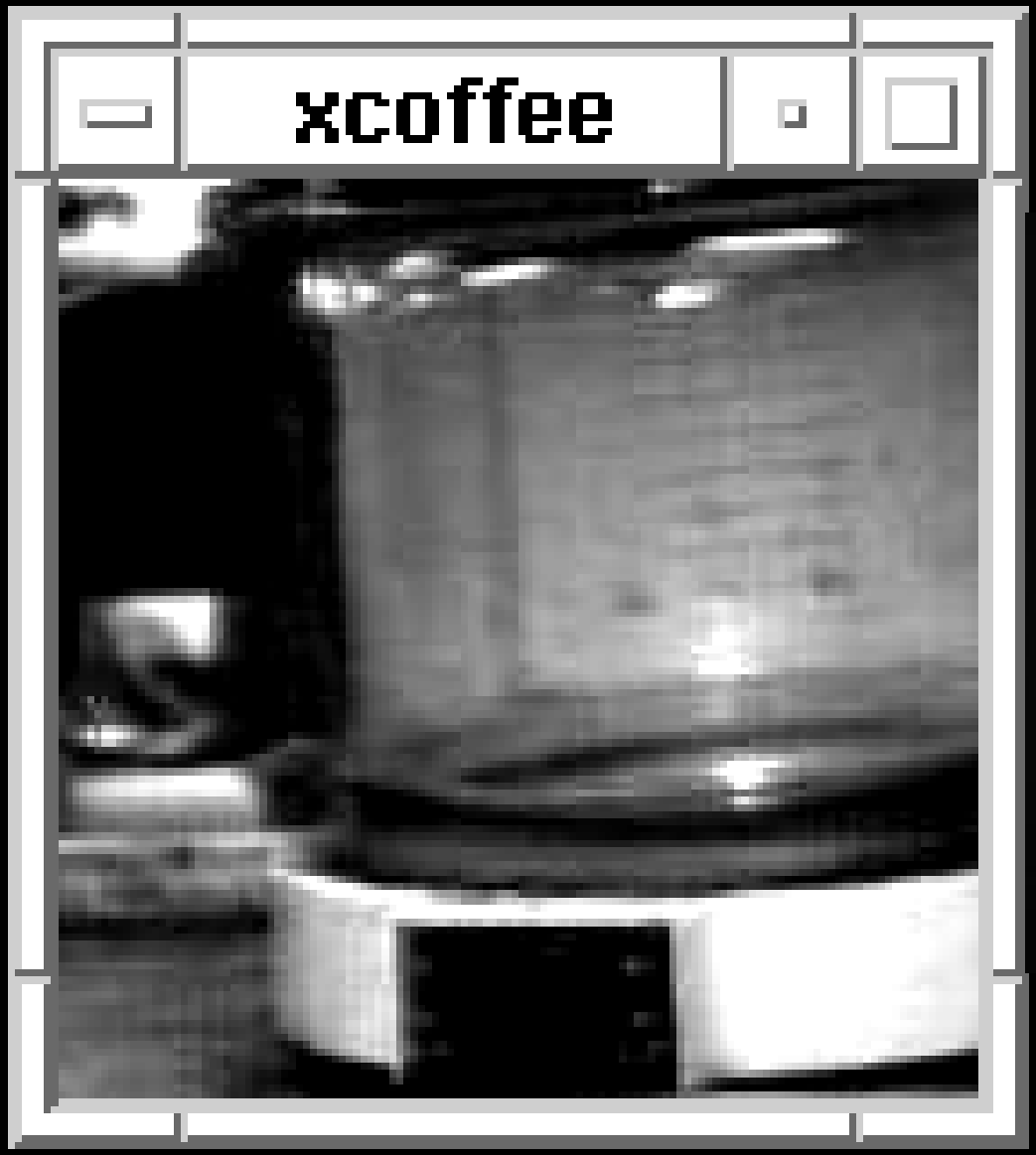
nikola tesla (1898)

teleoperation: related work

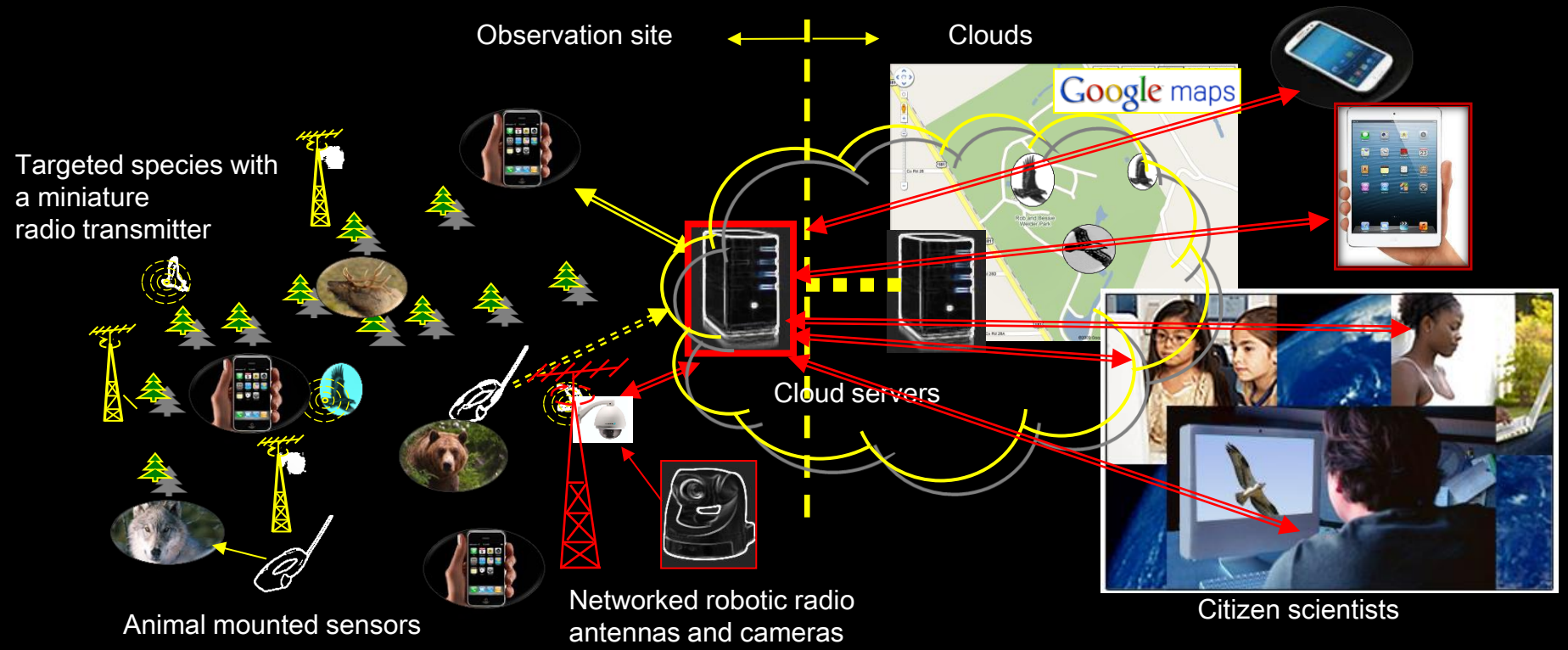
- Tesla, 1898
- Goertz, ‘54
- Mosher, ‘64
- Tomovic, ‘69
- Salisbury,Bejczy, ‘85
- Ballard, ’86
- Volz, ’87
- Sheridan, ‘92
- Sato, ’94
- Goldberg, ’94-
- Presence Journal ‘92-
- O. Khatib, et al. ’96

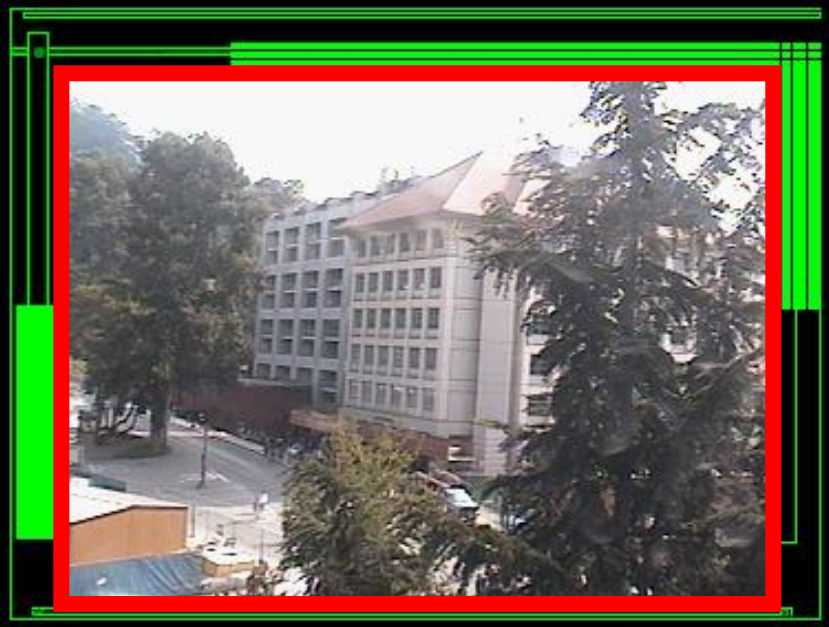





xcoffee

Collaborative Teleoperation

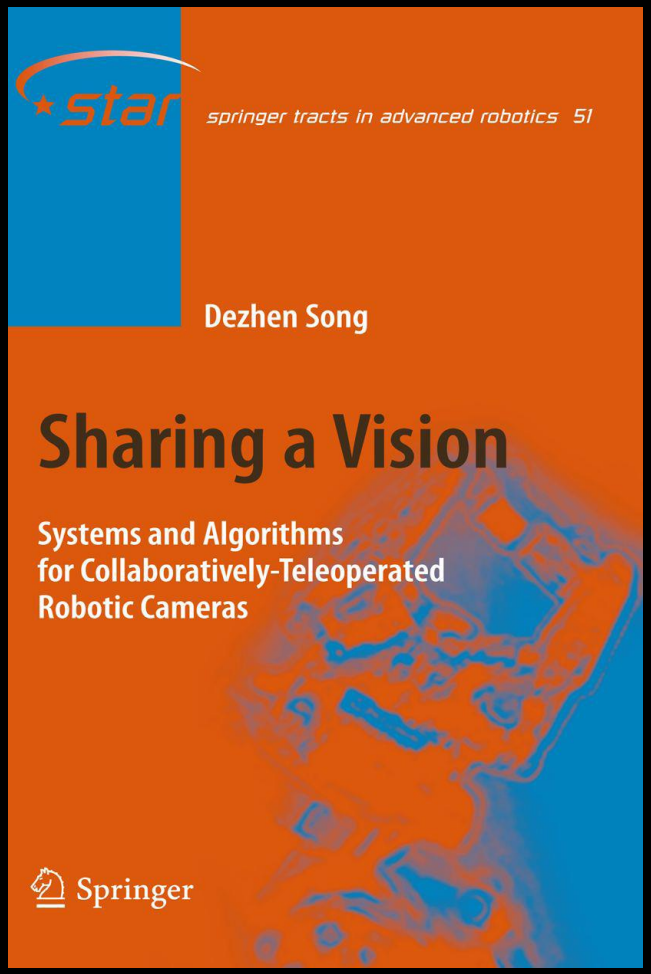




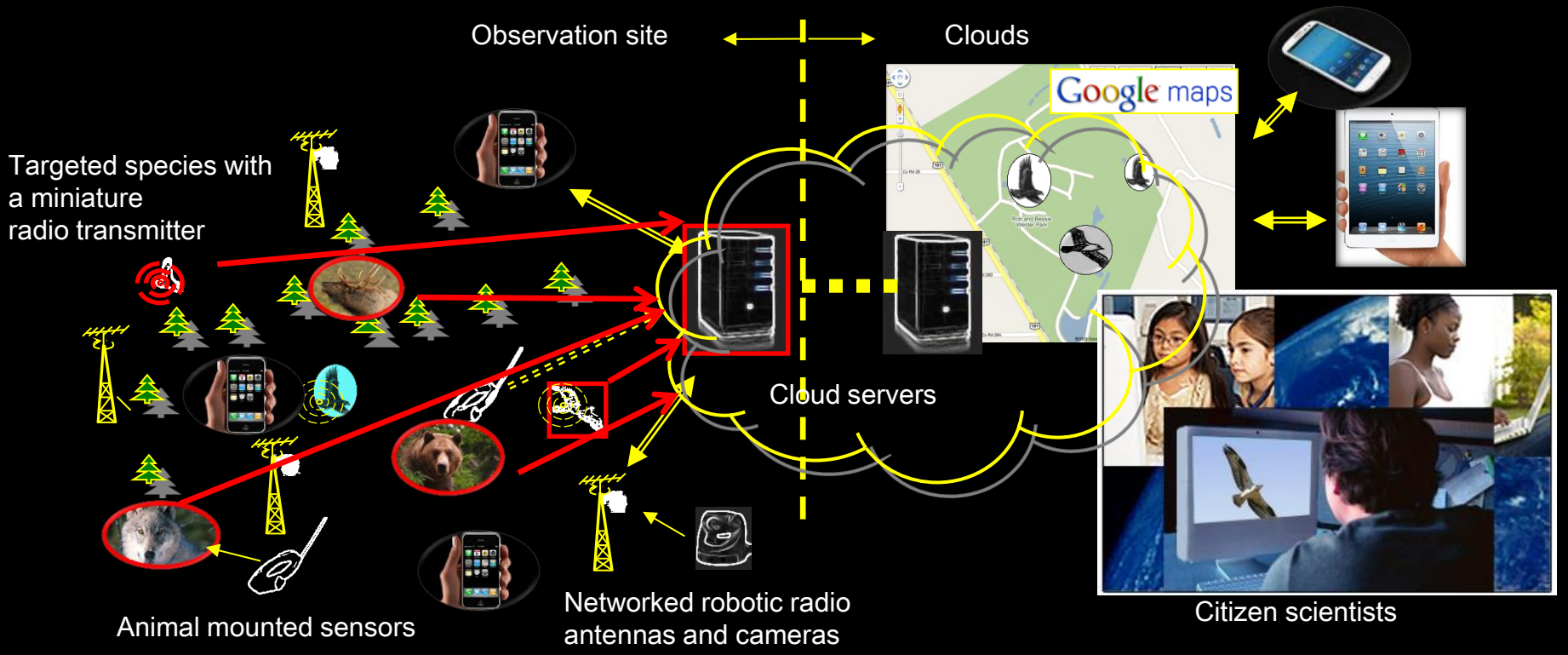
Frame Selection Problem: Given *n* requests, find optimal frame

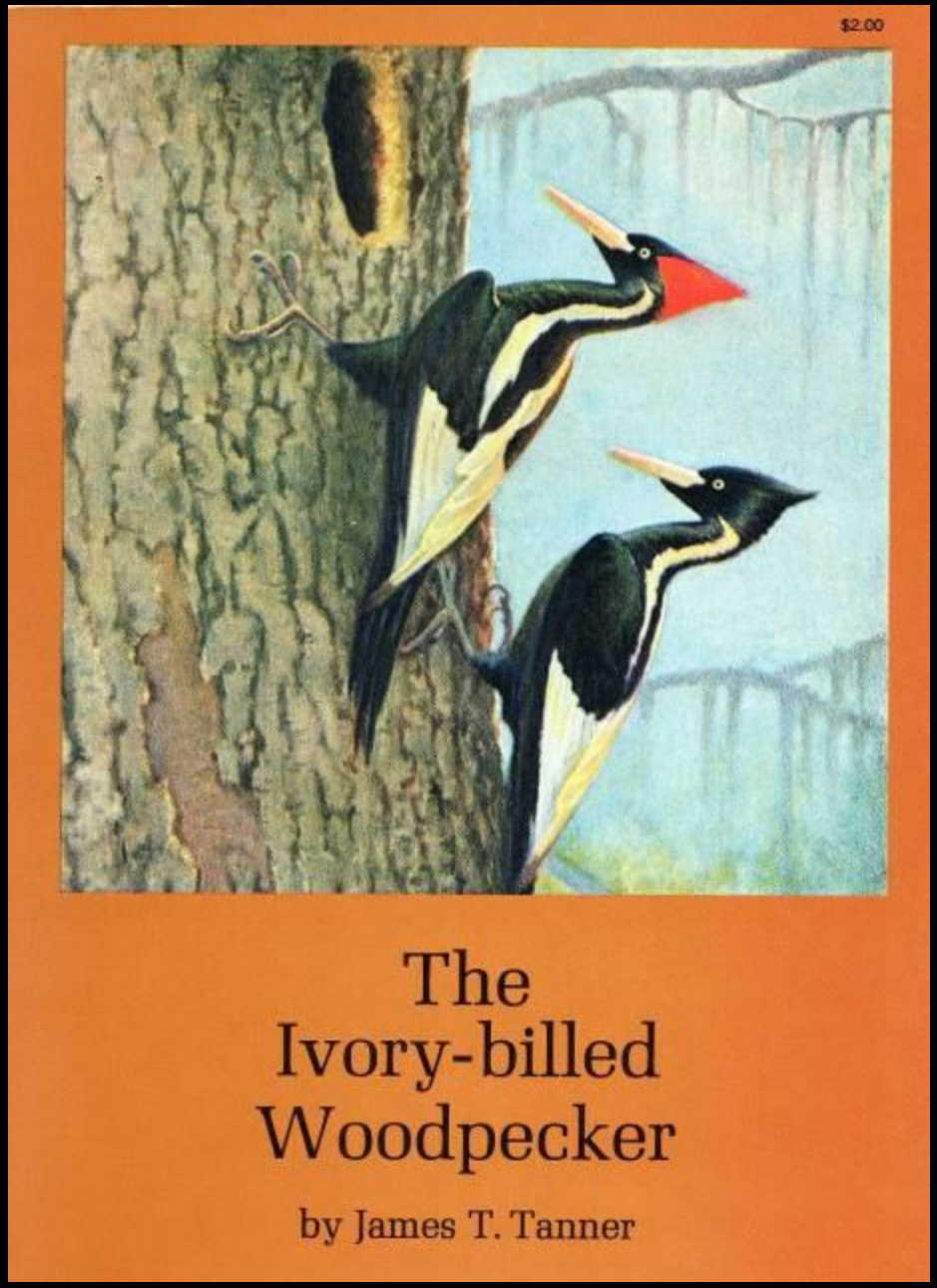
frame selection algorithms

Processing	Zoom	Type	Complexity
Centralized	Discrete	Exact	$O(n^2)$
Centralized	Discrete	Approx	$O(nk \log(nk))$, $k=(\log(1/\varepsilon)/\varepsilon)^2$
Centralized	Contin.	Exact	$O(n^3)$
Centralized	Contin.	Approx	$O((n + 1/\varepsilon^3) \log^2 n)$
Distributed	Discrete	Exact	Server: $O(n)$, Client: $O(n)$
Distributed	Contin.	Approx	Server: $O(n)$, Client $O(1/\varepsilon^3)$
p-Frame	Discrete	Approx	$O(n/\varepsilon^3 + p^2/\varepsilon^6)$



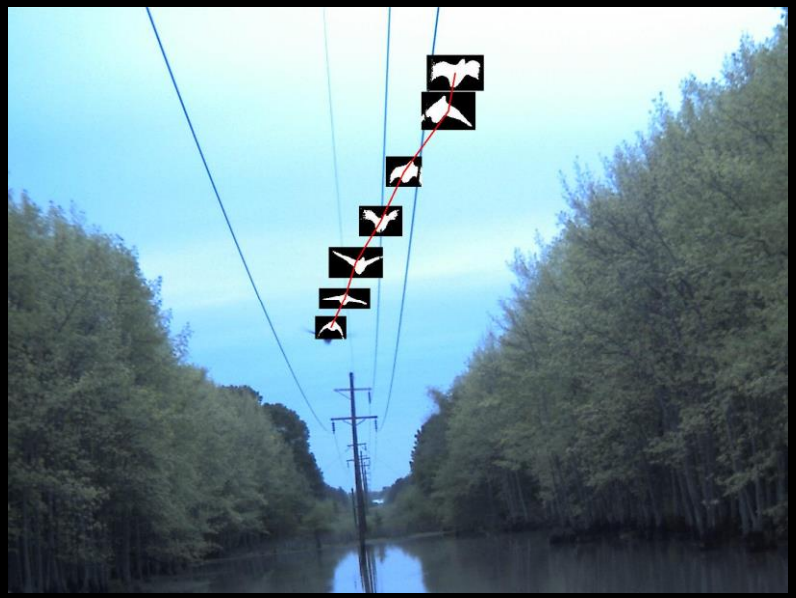
Robotic BioTelemetry




$2.00
The
Ivory-billed
Woodpecker
by James T. Tanner

Detecting Rare Birds

- Low occurrence (e.g., <10 times per year)
- Short duration (e.g., < 1 sec. in FOV)
- Huge video data for human identification.
- Setup and maintenance in remote environments.



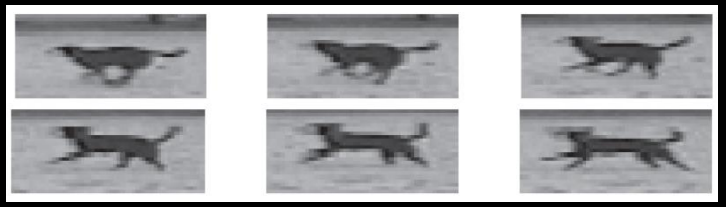
Natural cameras

- Crittercam
- DeerCam
- Africa web cams at the Tembe Elephant part
- Tiger web cams
- James Reserve Wildlife Observatory
- Crane Cam
- Swan Cam

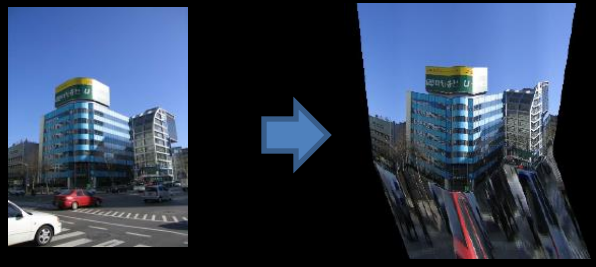
Related Work

- Motion detection and tracking
  - Elgammal, Grimson, Isard …

- Periodic motion detection
  - Culter, Ran, Briassouli …



- 3D inference using monocular vision
  - Ribnick, Hoiem, Saxena …

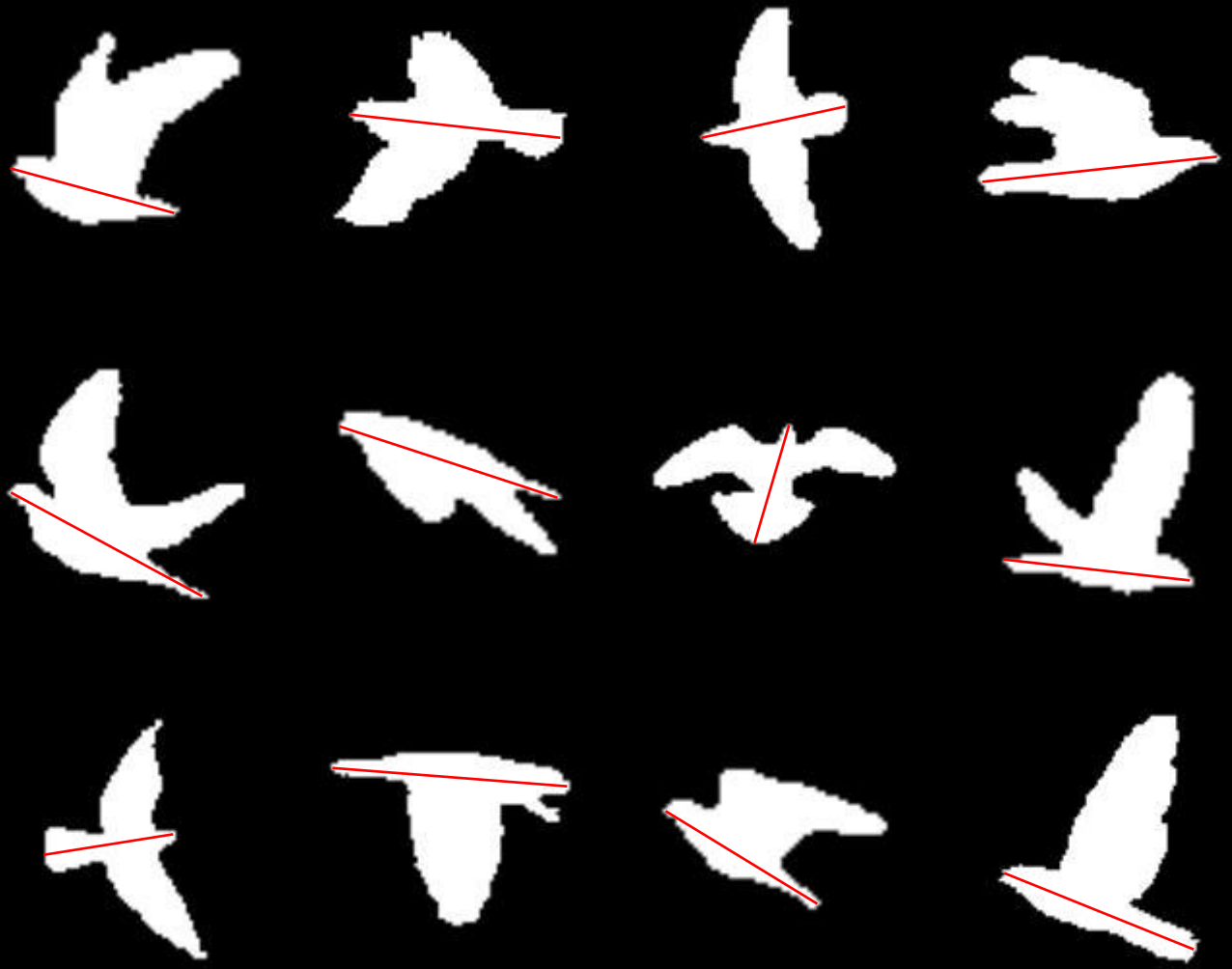


Bird detection problem

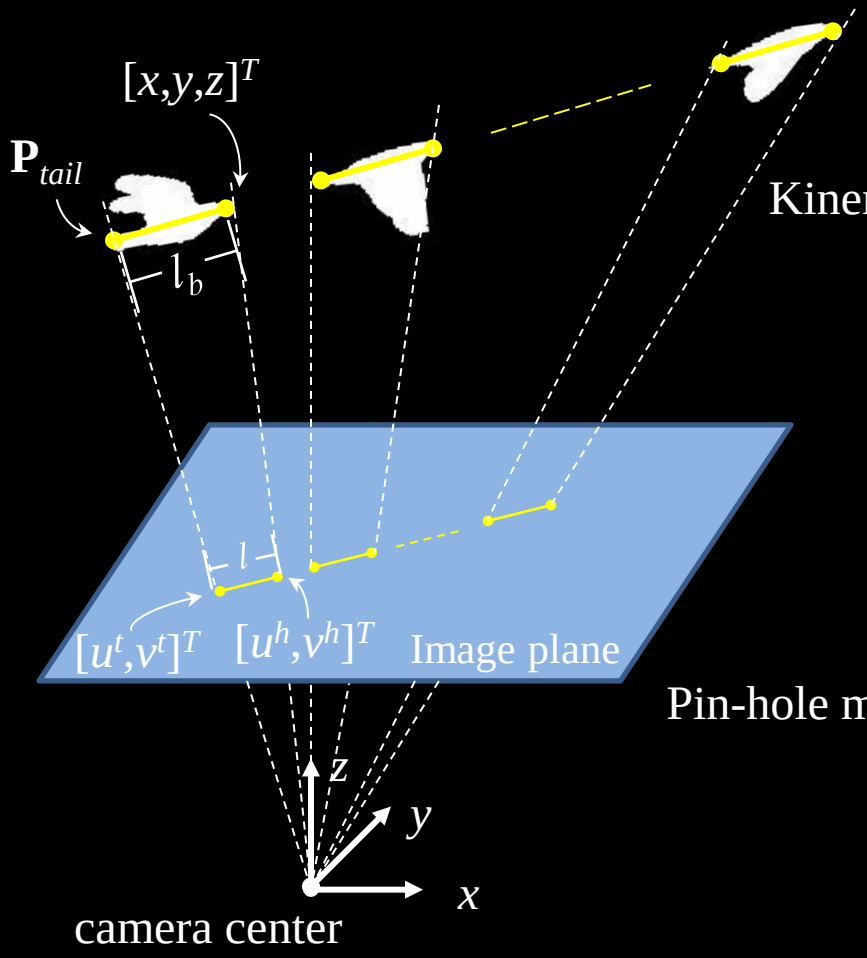
- Input
  - targeted bird body length l_b and speed range $\mathcal{V}=[v_{min},v_{max}]$.
  - a sequence of n images containing a moving object

- Output
  - to determine if the object is a bird of targeted species

Conjecture 1: Invariant body length



Modeling A Flying Bird



$$\mathbf{p} = [x, y, z]^T \qquad \mathbf{v} = [\dot{x}, \dot{y}, \dot{z}]^T$$

Kinematics: $\dot{\mathbf{x}} = \begin{bmatrix} \dot{\mathbf{p}} \\ \dot{\mathbf{v}} \end{bmatrix} = [\dot{x}, \dot{y}, \dot{z}, 0, 0, 0]^T = \begin{bmatrix} \mathbf{v} \\ \mathbf{0} \end{bmatrix}$

Tail: $\mathbf{P}_{tail} = [x^t, y^t, z^t]^T = \begin{bmatrix} x - \dot{x} l_b / \|\mathbf{v}\| \\ y - \dot{y} l_b / \|\mathbf{v}\| \\ z - \dot{z} l_b / \|\mathbf{v}\| \end{bmatrix}$

Pin-hole model:

$$\mathbf{z} = \begin{bmatrix} fx/z \\ fy/z \\ fx^t/z^t \\ fy^t/z^t \end{bmatrix} = \begin{bmatrix} fx/z \\ fy/z \\ f\frac{x\|\mathbf{v}\| - l_b\dot{x}}{z\|\mathbf{v}\| - l_b\dot{z}} \\ f\frac{y\|\mathbf{v}\| - l_b\dot{y}}{z\|\mathbf{v}\| - l_b\dot{z}} \end{bmatrix} + \mathbf{w}$$

$$:= h(\mathbf{x}) + \mathbf{w}$$

PODS-EKF Approximate Computation

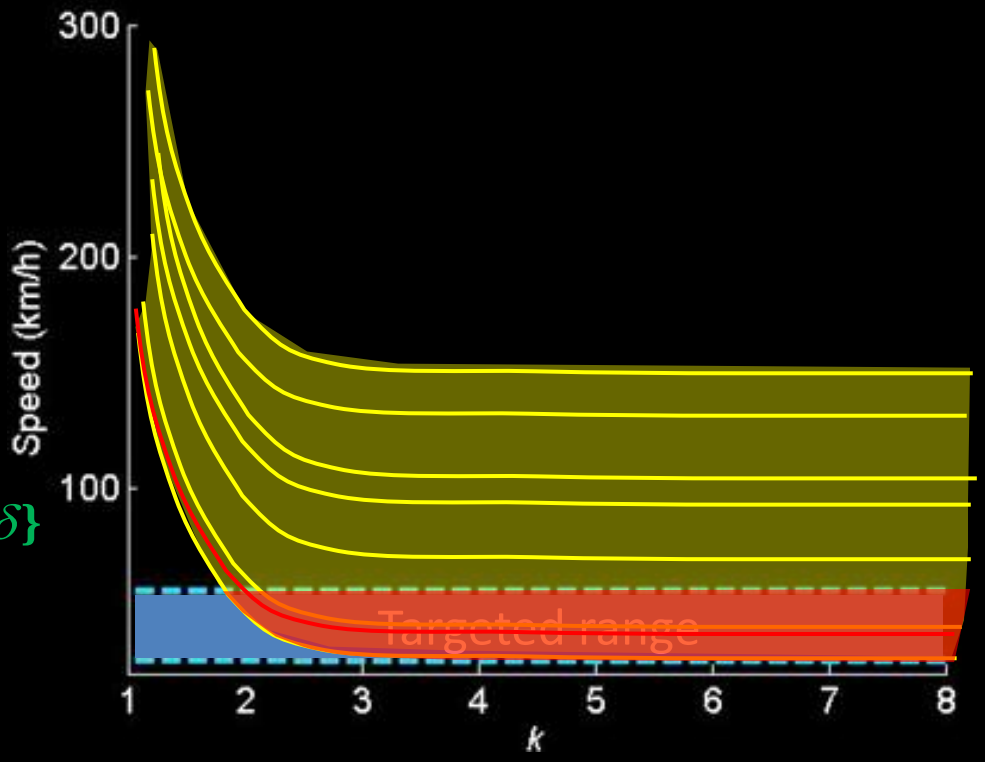
$$\tilde{\mathbf{Z}}^{1:n} = \underset{\mathbf{z}(k)\in\mathbb{S}(k)}{\arg\min}\, \varepsilon(\mathbf{X}^{1:n})$$

Subject to:

$$\hat{\mathbf{x}}(k|k-1) = A(k)\hat{\mathbf{x}}(k-1|k-1),$$
$$\hat{P}(k|k-1) = A(k)\hat{P}(k-1|k-1)A^T(k) + Q(k),$$
$$K(k) = \frac{\hat{P}(k|k-1)H^T(k)}{H(k)\hat{P}(k|k-1)H^T(k) + W(k)},$$
$$\hat{\mathbf{x}}(k|k) = \hat{\mathbf{x}}(k|k-1) + K(k)(\mathbf{z}(k) - h(\hat{\mathbf{x}}(k|k-1))),$$
$$\hat{P}(k|k) = (\mathbf{I}_{6\times 6} - K(k)H(k))\hat{P}(k|k-1),$$

$$\mathbb{Z}^{1:n} = \{\mathbf{Z}^{1:n} \mid \mathbf{z}(k) \in \mathbb{S}(k) \text{ and } \varepsilon(\mathbf{X}^{1:n}) < \delta\}$$

$$\|\tilde{\mathbf{v}}(n|n)\| \in \mathcal{V}$$

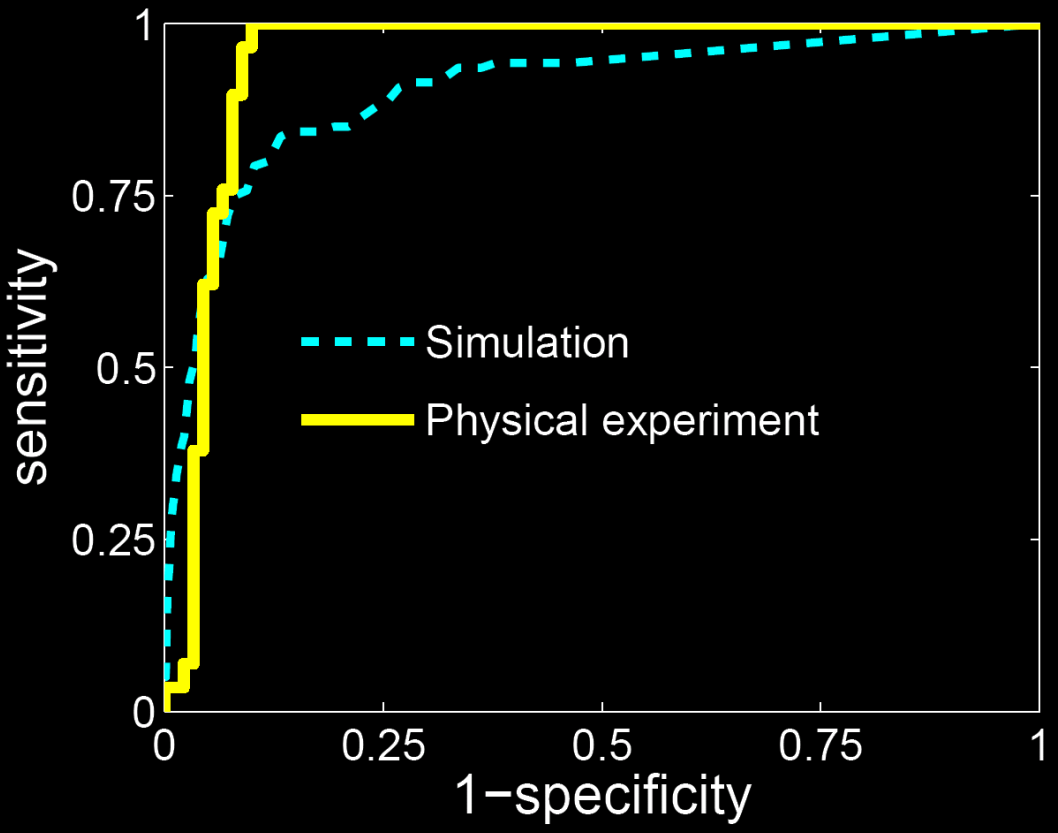


Dezhen Song and Yiliang Yu, *A Low False Negative Filter for Detecting Rare Bird Species from Short Video Segments using a Probable Observation Data Set-based EKF Method*, IEEE Transactions on Image Processing, vol. 19, no. 9, Sept. 2010, pp. 2321-2331

Experiments and Results

- Testing phase: May 2006 to Oct. 2006 in Texas A&M campus
- Field phase: Oct. 2006 to Oct. 2007 in Brinkley, AR

ROC Curves for Rock Pigeon



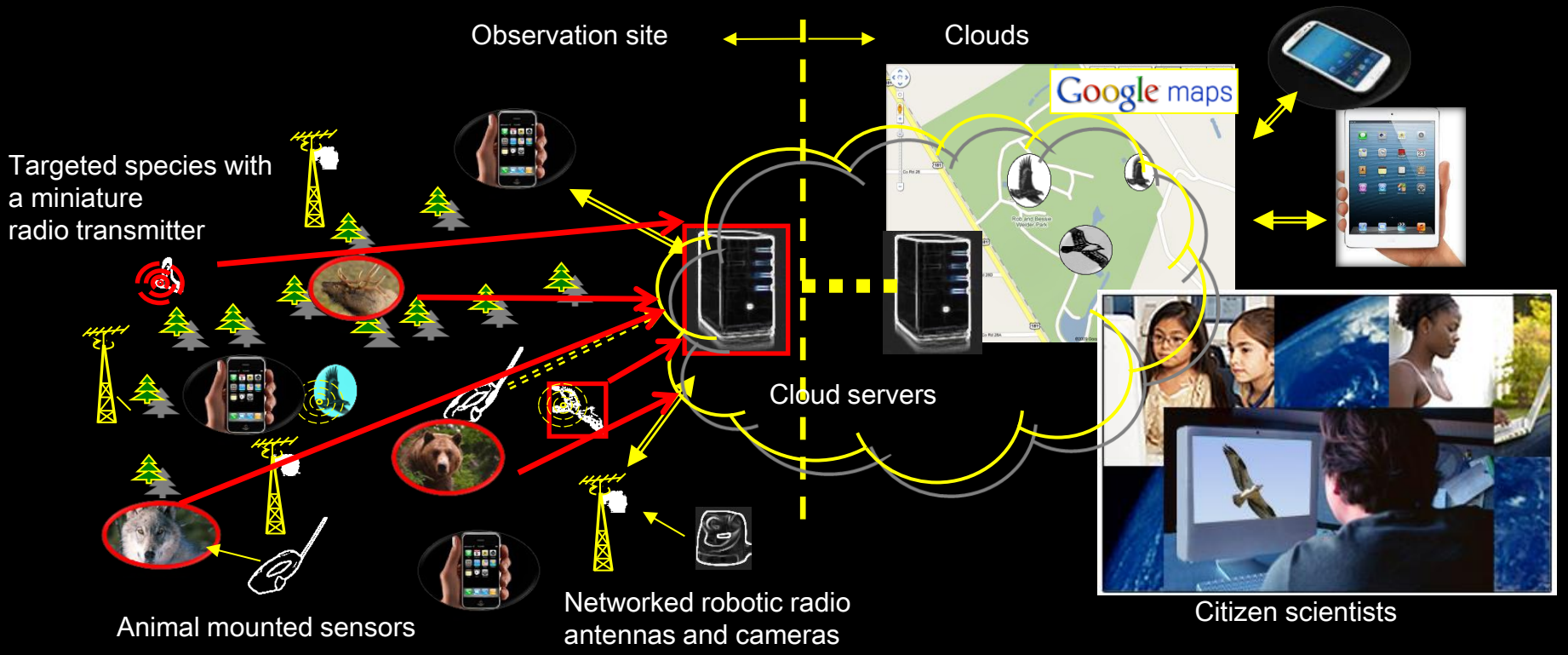
Area under ROC curve: 91.5% in Simulation; 95.0% in Experiment.


POLARIS

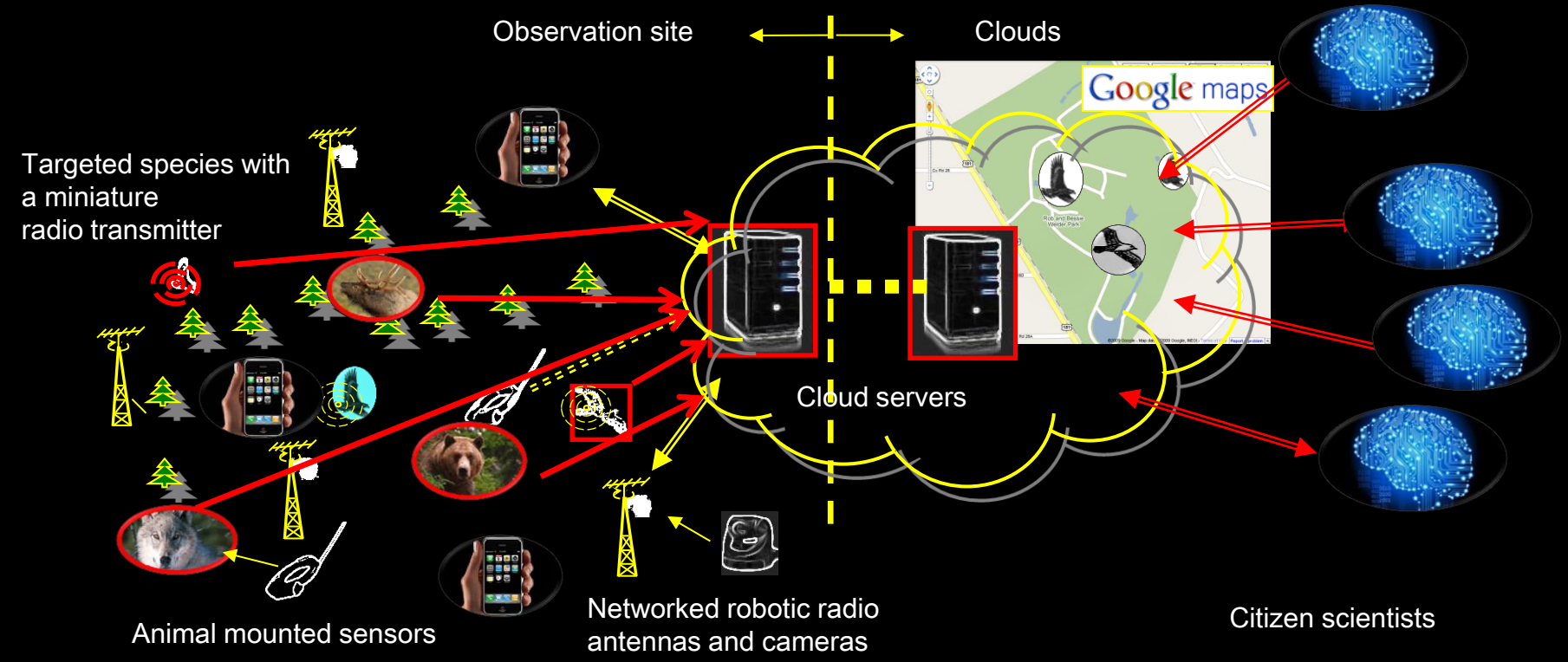
Results:

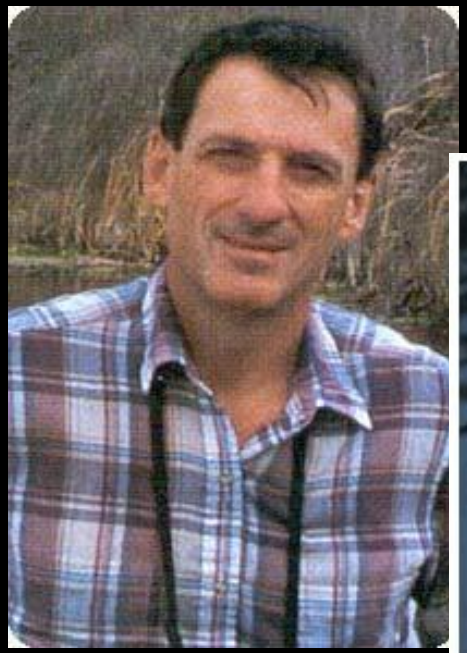
- No Ivory-billed Woodpecker!
- Sensitivity: <10% false negative rate
- Data reduction:
  - 146.7MB out of 29.41TB raw data
  - data reduction rate 99.9995%
- Robustness: running continuously in the Arkansas wilderness for 12 months

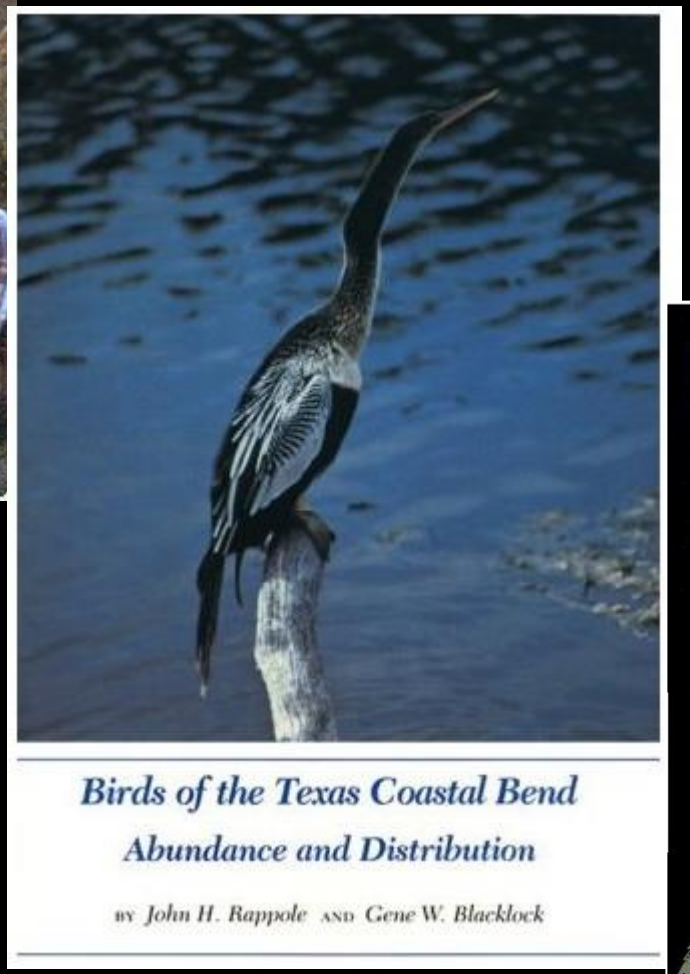
Robotic BioTelemetry

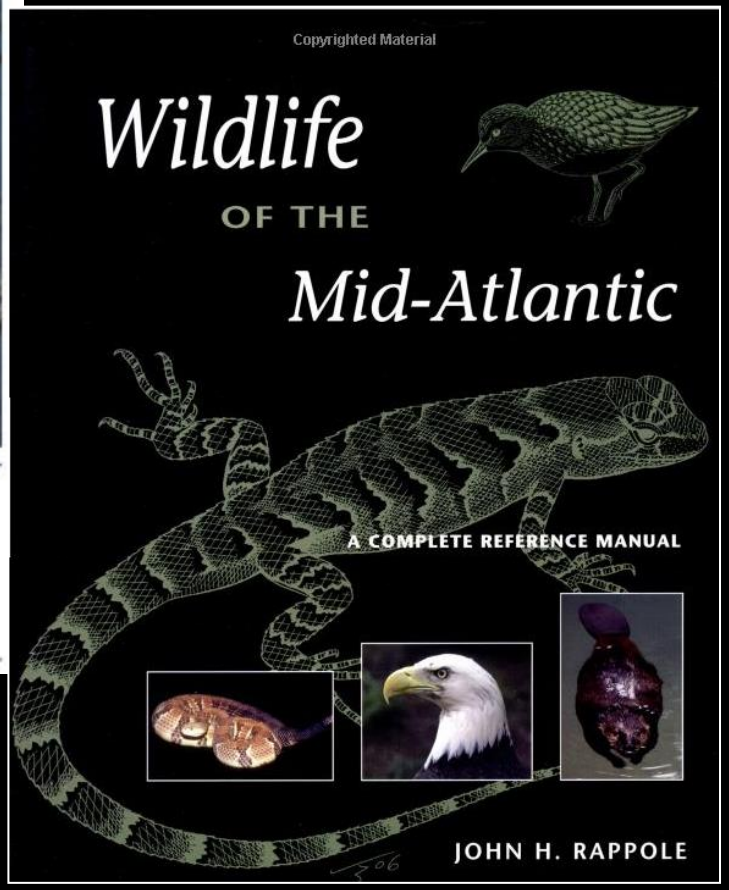


Crowd Sourcing Collaborative Computing






Birds of the Texas Coastal Bend
Abundance and Distribution
by John H. Rappole and Gene W. Blacklock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Wildlife
OF THE
Mid-Atlantic
A COMPLETE REFERENCE MANUAL
JOHN H. RAPPOLE

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Refresh | prev | 1 / 3574 | next | Show Categories

11/26/08 10:46am

txbird #118280

11/26/08 10:28am

kryptonkay #118267

11/26/08 10:23am

kryptonkay #118264

11/26/08 10:22am

vanilla #118259

11/26/08 10:22am

peteinkeyworth #118258

11/26/08 10:22am

vanilla #118252

CONE WELDER

COLLABORATIVE OBSERVATORIES FOR NATURAL ENVIRONMENTS

Please email support.cone.welder@gmail.com with problems/suggestions/etc.
(please note which browser version and operating system you are using)

Tutorial | FAQ | About | Blog | Search | Chat History

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2/19/09 9:47am by kryptonkay

Rating(5) ★★★★☆

eyes23blue says:

beautiful! the colour and the pose! *-*

vanilla says:

Sweet!

birdbrain says:

Great!!!

avatar99 says:

Nice one, KK

Northern Cardinal / Cardinalis cardinalis

Animal: Birds

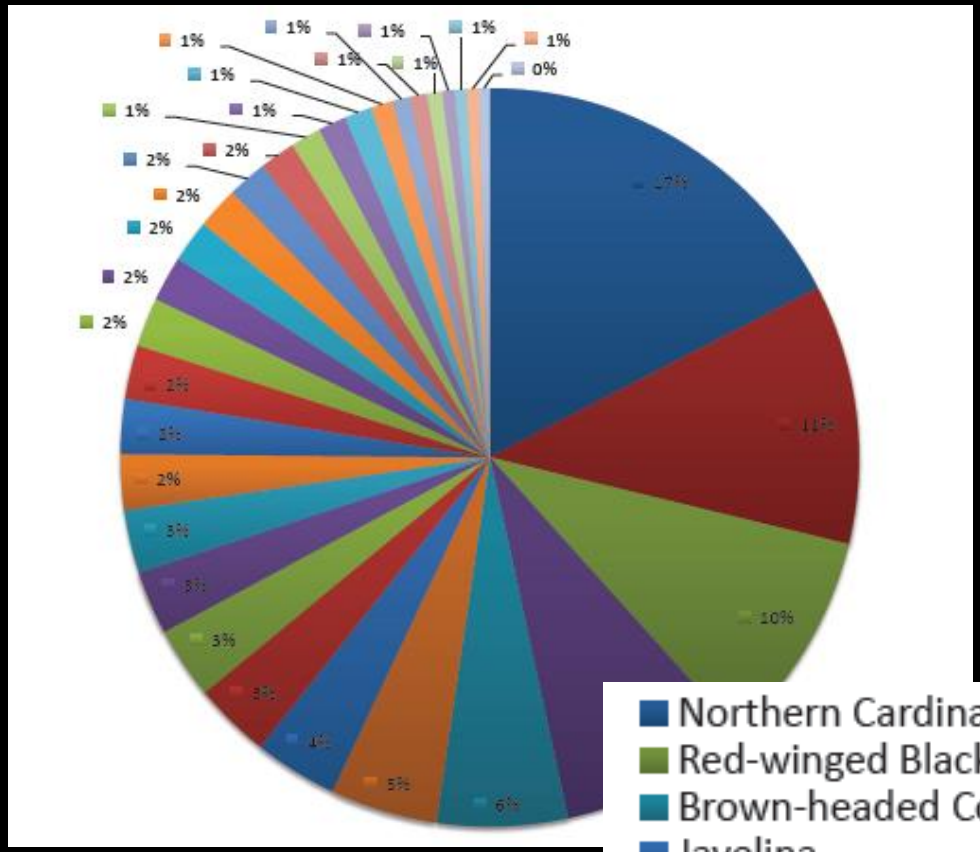
Name: Northern Fulmar / Fulmarus glacialis

Northern Fulmar / Fulmarus glacialis

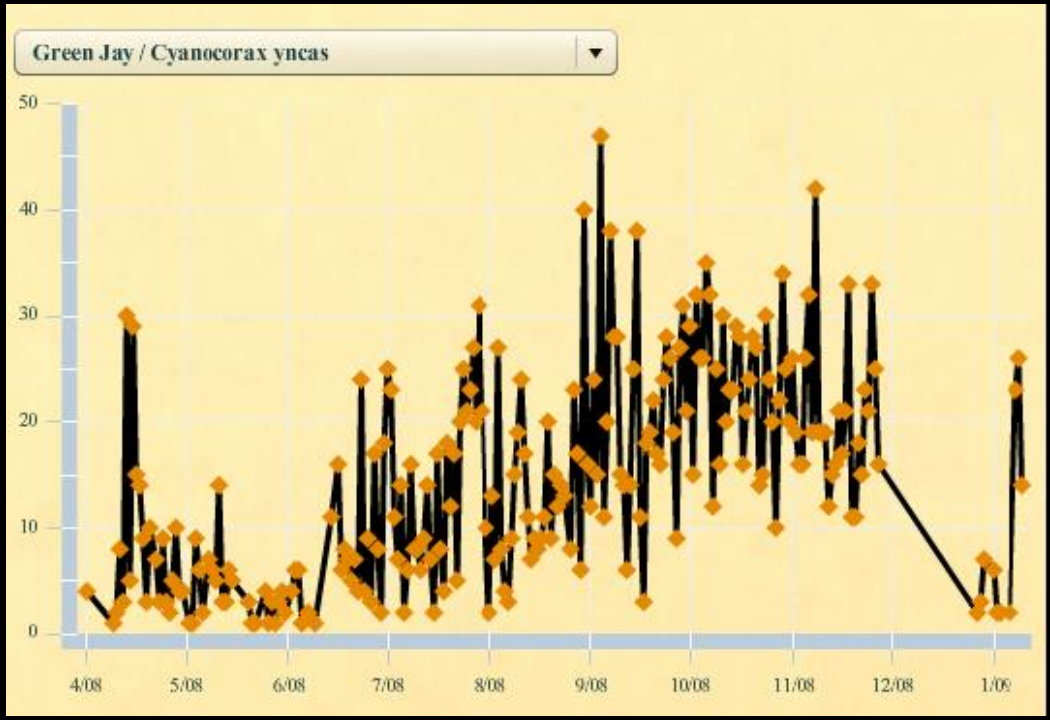
Return

classify

Add Comment



- Northern Cardinal
- Green Jay
- Red-winged Blackbird
- Inca Dove
- Brown-headed Cowbird
- White-tail Deer
- Javelina
- Bronzed Cowbird
- No Classifiable Species
- Raccoon
- Buff-bellied Hummingbird
- Chipping Sparrow
- Black-chinned Hummingbird
- Great-tailed Grackle
- Barred Owl
- Feral Hog
- Northern Mockingbird
- Ruby-throated Hummingbird
- American Goldfinch
- Fox Squirrel
- Golden-fronted Woodpecker
- Great Kiskadee
- Insect
- Painted Bunting


Green Jay / Cyanocorax yncas
50
40
30
20
10
0
4/08
5/08
6/08
7/08
8/08
9/08
10/08
11/08
12/08


Cliff Swallow


Brown-crested flycatcher


Laughing Gull


Painted Bunting


Veery


Eastern Wood-Pewee


Bonaparte's Gull


Scissor-tailed flycatcher


Yellow-crowned Night-Heron


Swallow-tailed Kite


Green jay


Least grebe


Common Moorhen


Crested Caracara


Great Egret


Plain chachalaca


Great egret


Magnolia warbler


Turkey Vulture


Savannah Sparrow


Wilson's Snipe


Great kiskadee


Marbled Godwit


Black and White Warbler


Orchard Oriole


Vermilion flycatcher


Snowy egret


Ring-billed Gull


Gray catbird


Barred Owl


King Rail


Green Kingfisher


Varied Bunting


Yellow warbler


Cactus wren


Great egret


Blue-winged teal


Mexican Jay


Purple gallinule


Brown Pelican

Red-tailed hawk

Whooping crane

Yellow-throated Warbler

American Bittern

Green heron

Chestnut-sided Warbler

Cackling Goose

Black-throated Green-Warbler

Sandwich Tern

Prothonotary warbler

Black Skimmer

Scarlet tanager

Eastern phoebe

Pyrrhuloxia

Roseate Spoonbill

Great-horned owl

Wilson's Plover

Red-headed Woodpecker

Northern cardinal

Red-shouldered Hawk

Brown jay

Northern

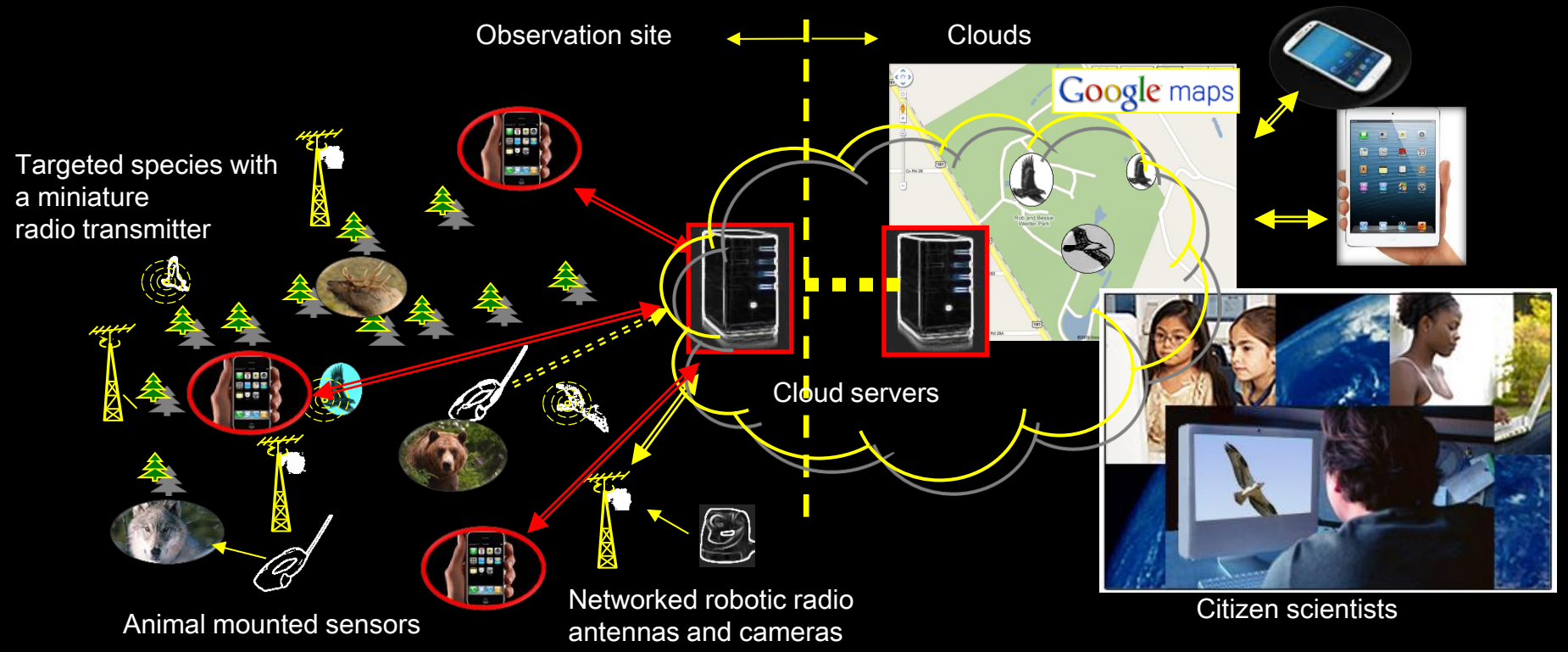
Great blue

Blackburnian

Eared grebe

Pied-billed

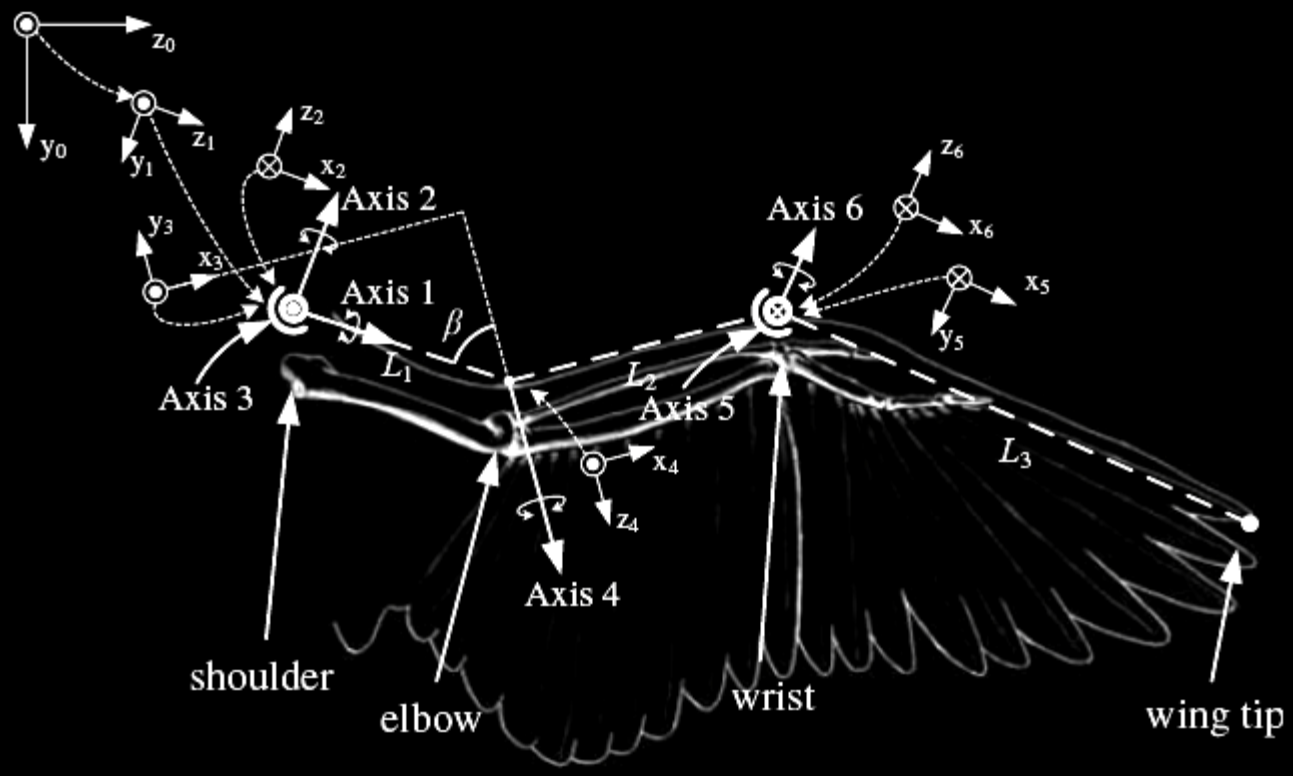
Crowd Sourcing for Ubiquitous Observation



Crowd Sourced Videos

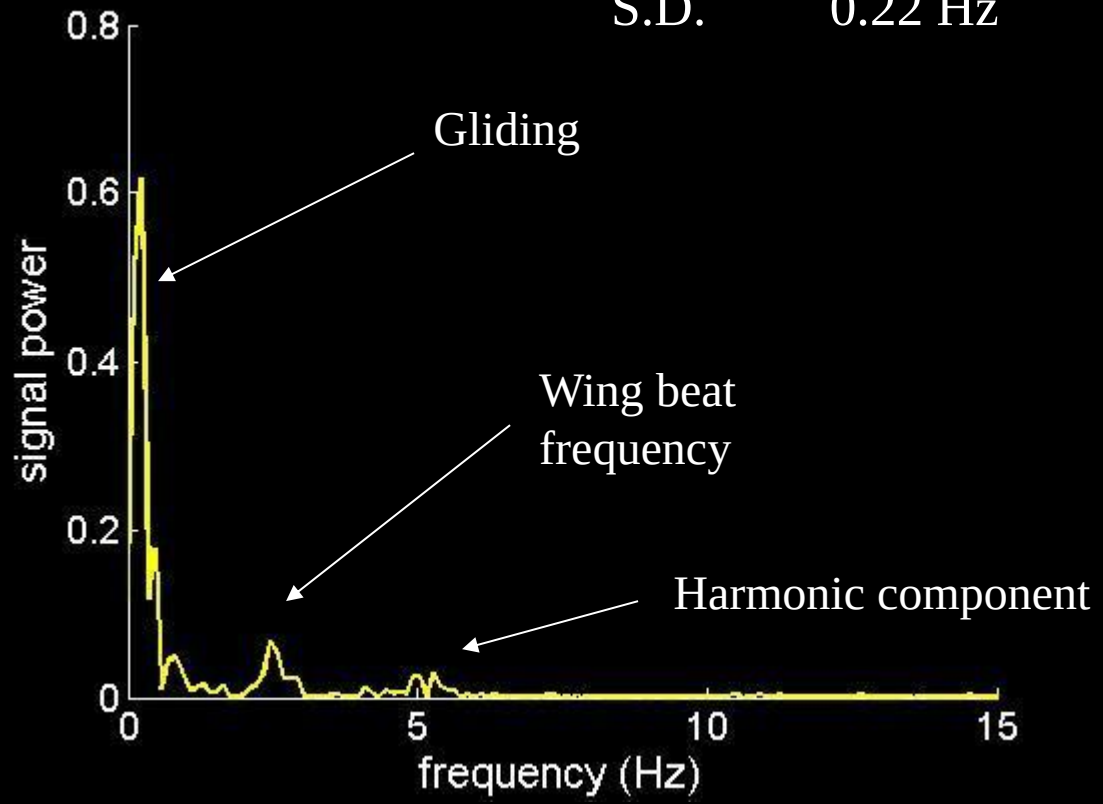
- Examine wing-flapping motion
  - Wing beat frequency is unique for each species

Wing Kinematic Model



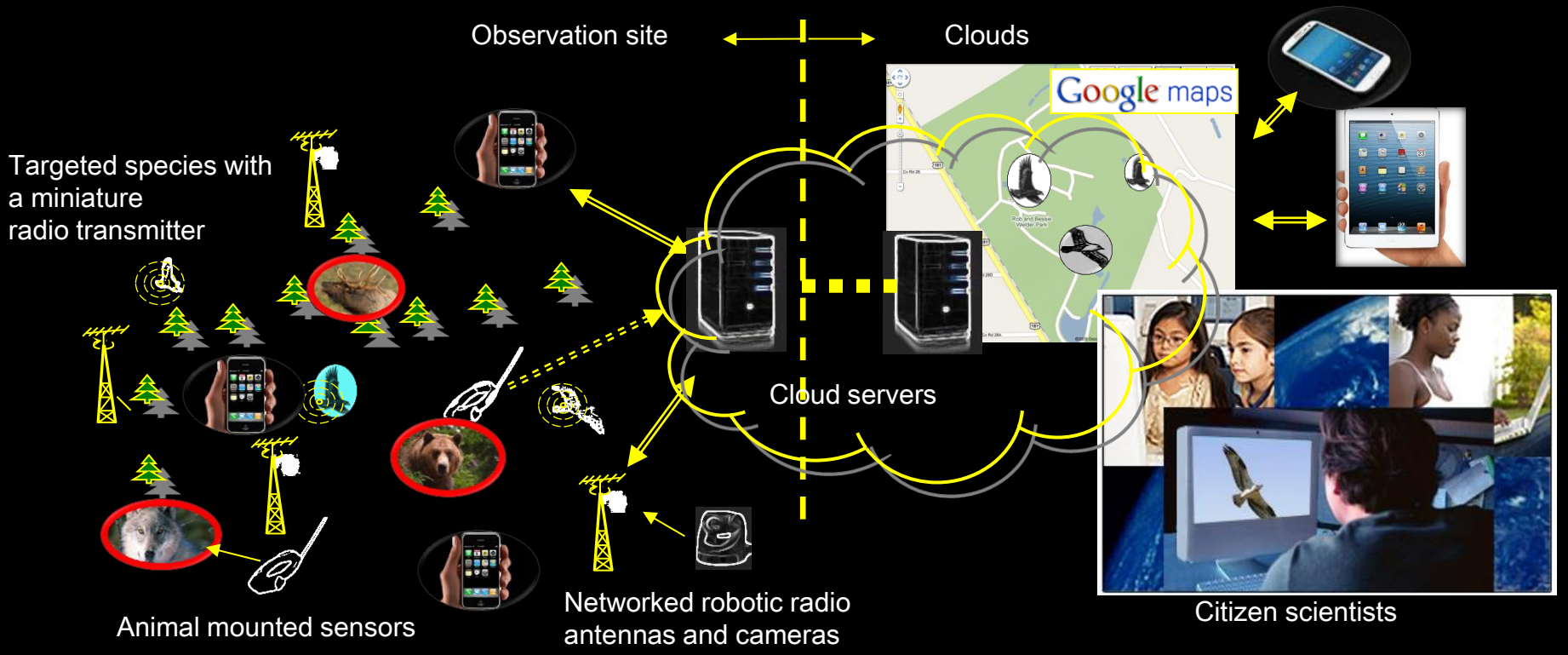
Sample Results

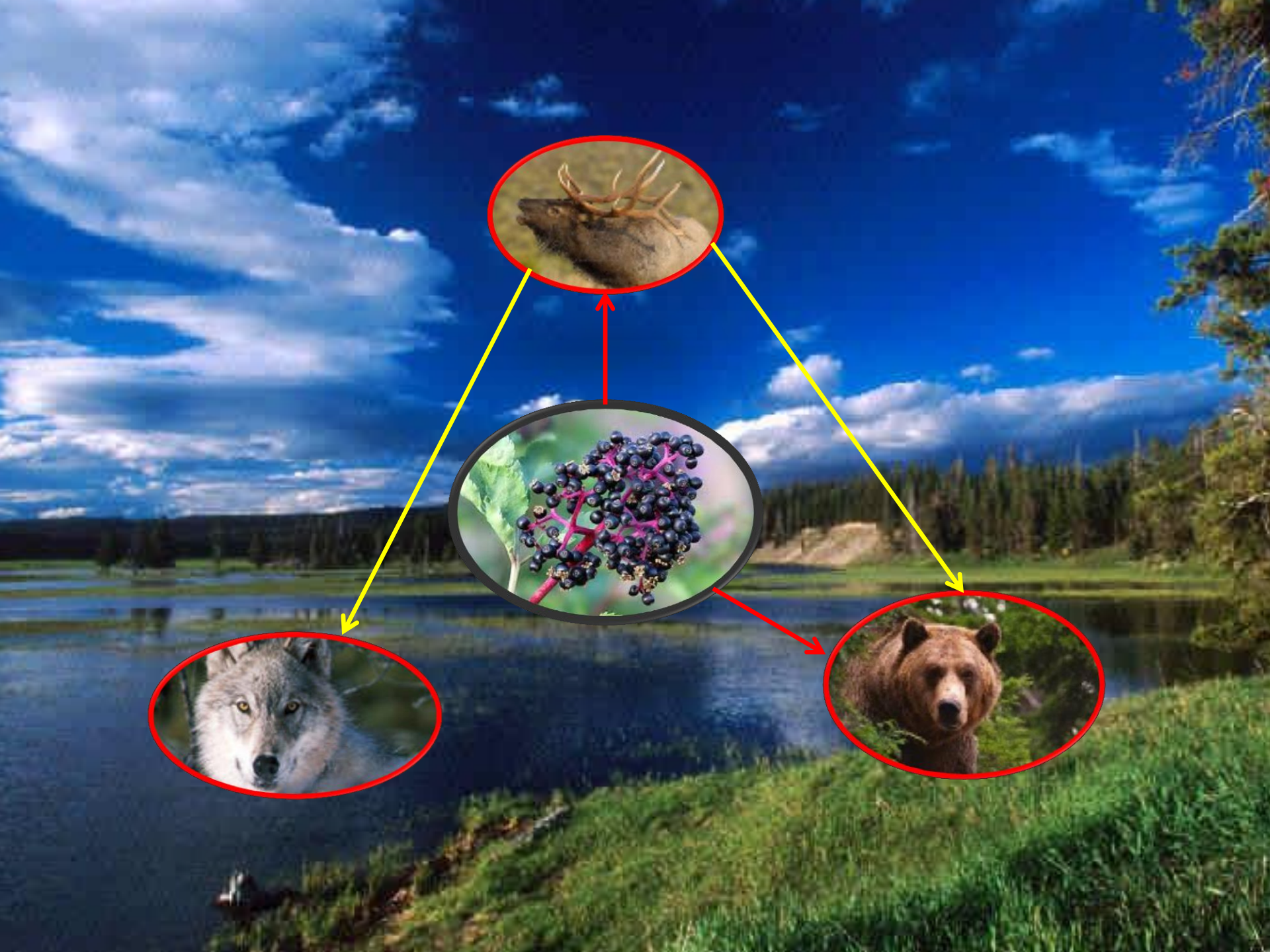
Seagull: Mean 2.74 Hz
S.D. 0.22 Hz

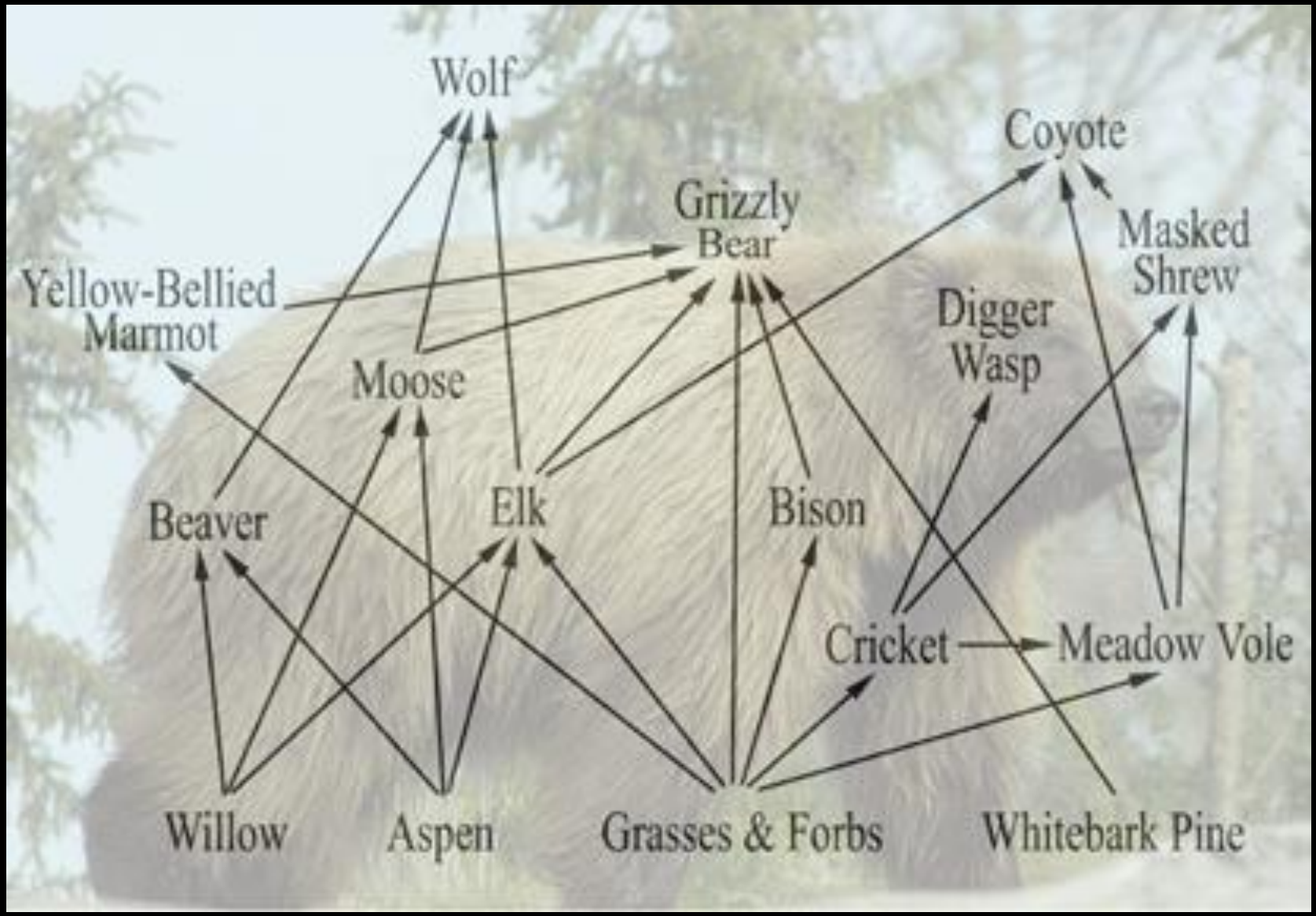


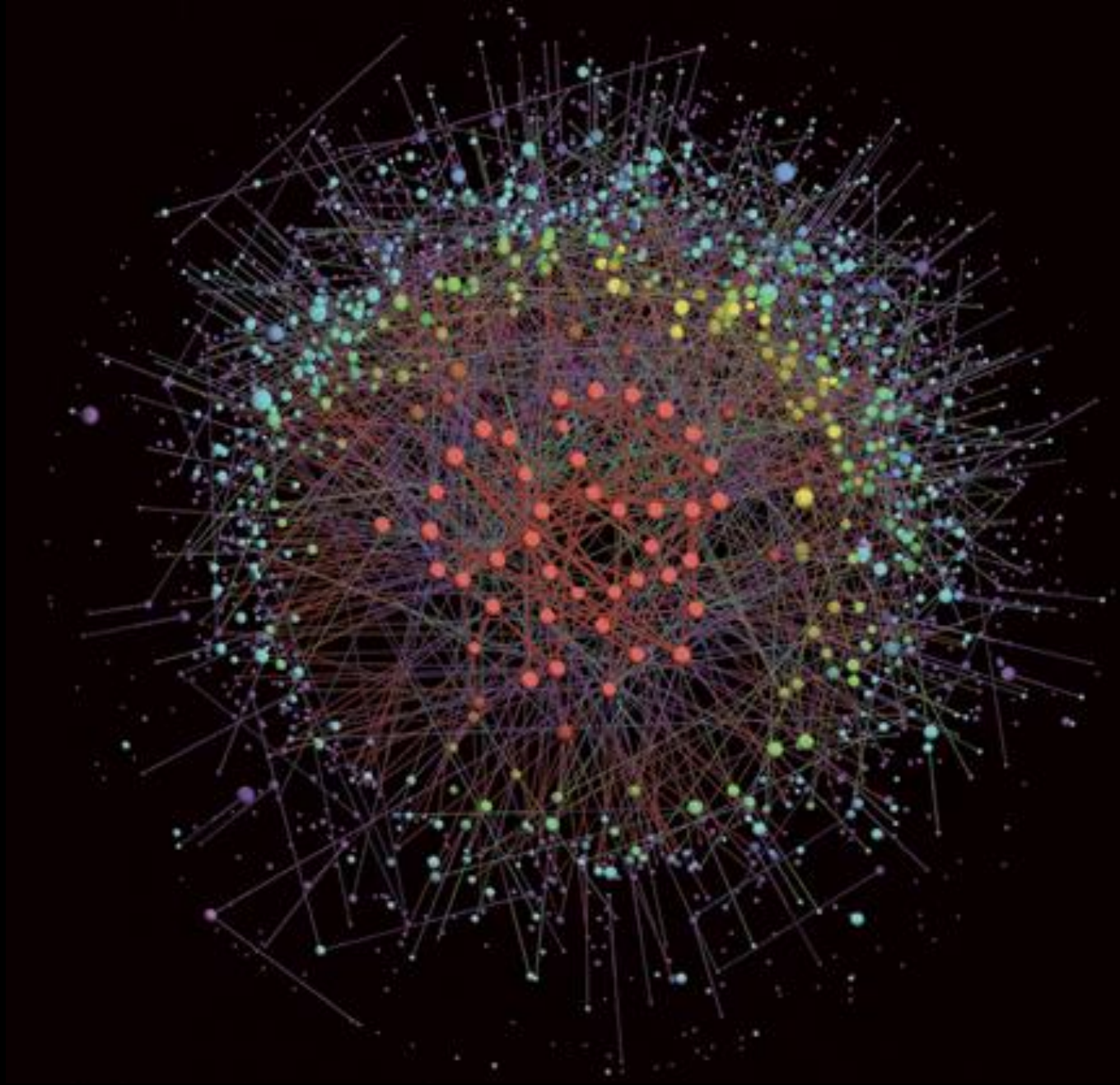
Wen Li and Dezhen Song, *Automatic Bird Species Detection from Crowd Sourced Videos*, IEEE Transactions on Automation Science and Engineering (T-ASE) (Accepted, To appear)

What is More about Cloud?



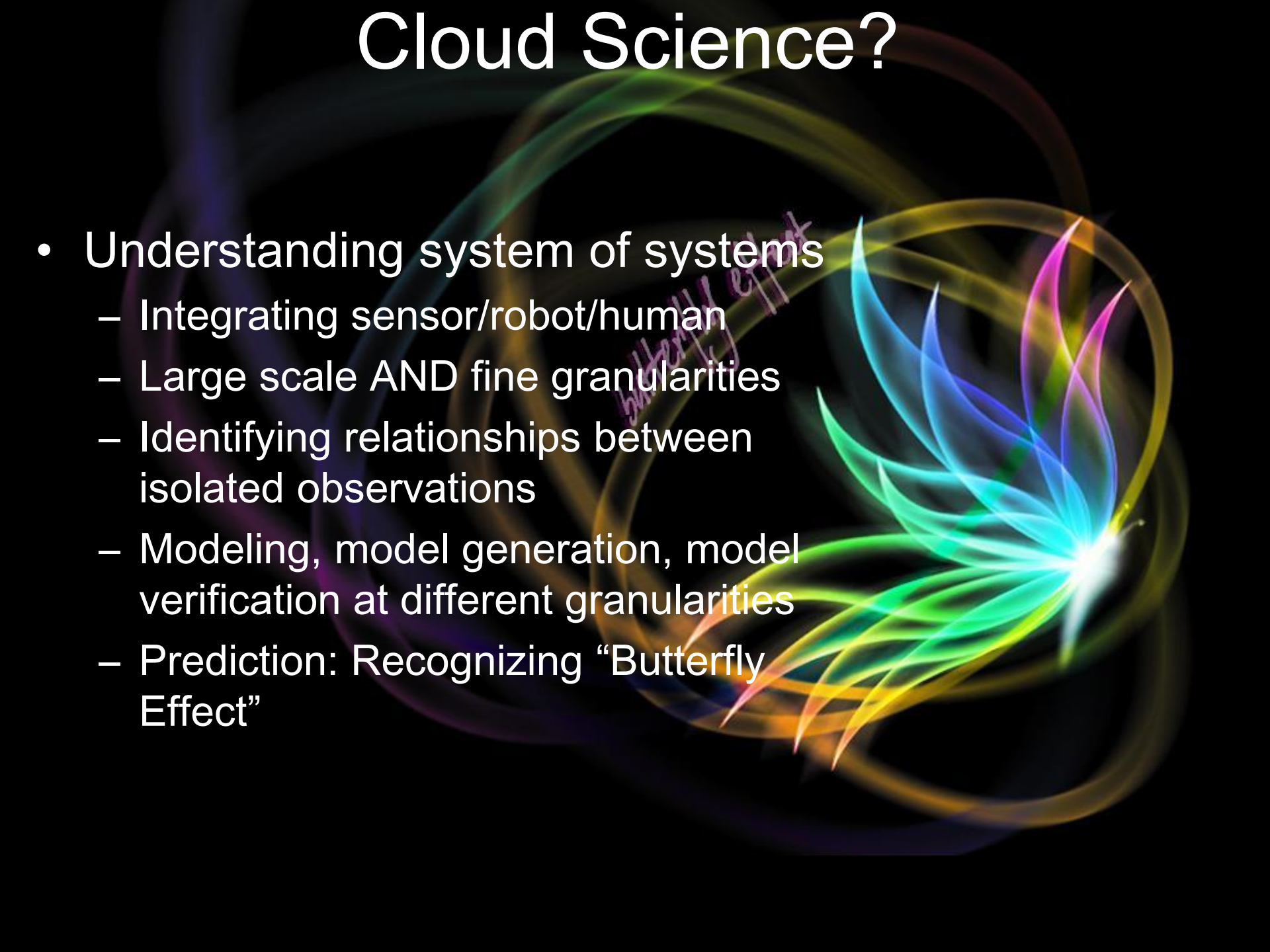


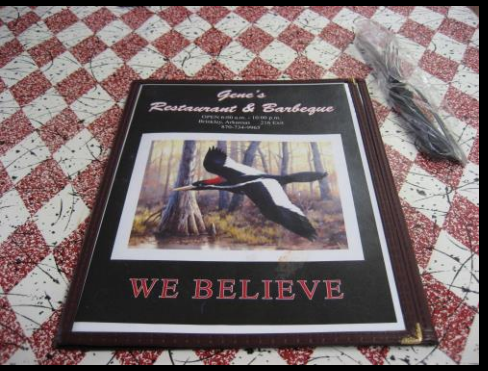

Wolf
Coyote
Grizzly Bear
Masked Shrew
Yellow-Bellied Marmot
Digger Wasp
Moose
Beaver
Elk
Bison
Cricket
Meadow Vole
Willow
Aspen
Grasses & Forbs
Whitebark Pine



Cloud Science?

- Understanding system of systems
  - Integrating sensor/robot/human
  - Large scale AND fine granularities
  - Identifying relationships between isolated observations
  - Modeling, model generation, model verification at different granularities
  - Prediction: Recognizing “Butterfly Effect”





Thanks!

Websites:

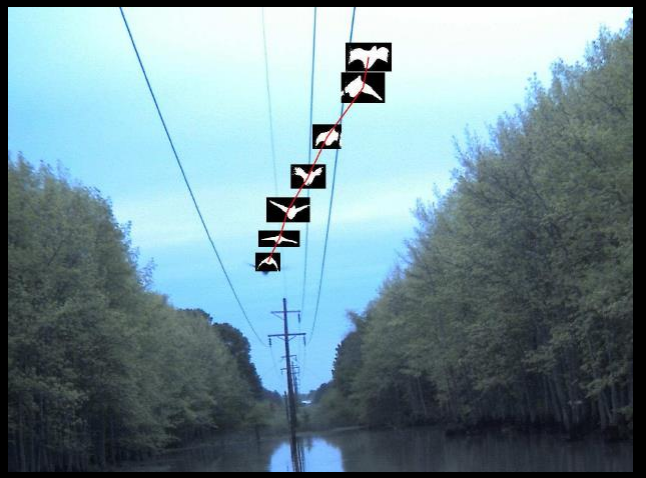
http://telerobot.cs.tamu.edu

http://rbt.cs.tamu.edu/

Assumptions

- Static monocular camera
  - High resolution
  - Narrow FOV

- Single bird in FOV
  - Motion segmentation



- Constant bird velocity
  - High flying speed
  - Narrow camera FOV