Uncertainty-Aware Visualization of Fish Populations

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ABSTRACT

Applying computer vision for monitoring ecosystems opens new perspectives for marine ecology research. Information on fish populations can be automatically extracted from underwater cameras. As scientists, ecologists need to understand the uncertainty in computer vision results. We present an interface for studying fish populations that addresses two challenges: provide information about fish populations as well as computer vision uncertainty; and enable open-ended data exploration. We introduce an uncertainty visualization for non-experts and a generalizable interaction design for data exploration.

Categories and Subject Descriptors

H.5.2 [**User Interface**]: Graphical user interfaces, Interaction styles; I.2.10 [**Vision and Scene Understanding**]

General Terms

Design

Keywords

Data Visualization; Uncertainty; Interaction Design

1. INTRODUCTION

The Fish4Knowledge project[1] has continuously recorded videos of coral reef fish from 9 fixed underwater cameras during 3 years. Computer vision is used to identify fish amongst other objects, and recognize fish species. It introduces errors such as encoding errors, missing fish, non-fish objects, and misidentified species. Our interactive visualization supports the exploration of these multifactorial uncertainties.

2. VISUALIZING UNCERTAINTY

Ecologists are not experts in computer vision. Provenance and uncertainty must be comprehensive yet understandable. We identified user information needs by interviewing ecologists and computer vision experts [1, 2] and applying Correa's framework for uncertainty-aware visualization [4]. We developed a visualization of computer vision uncertainty adapted to non-experts (Fig. 1), and an interface for exploring multifactorial uncertainty (Fig. 2). Visualizing multifactorial uncertainty is considered a key challenge [3]: *"The R&D community must [...] develop methods and principles for representing data quality, reliability, and certainty measures throughout the data transformation and analysis process"* [6]. Except [5] similar applications evaluated uncertainty with ecology-specific methods rather than computer vision methods. We make computer vision uncertainty accessible to non-experts. Our prototype contains 5 tabs reflecting the information processing steps: data collection (*Video* tab), data processing (*Video Analysis, Extracted Data* tabs) and data interpretation (*Visualization, Report* tabs). These detail the uncertainty specific to each step. With the *Video* tab users can control image quality by watching videos. The *Video Analysis* tab explains the computer vision techniques and provides simplified visualizations of their uncertainty (Fig. 1). This novel graph makes ground-truth evaluation, a method specialized for computer vision[2], accessible to non-experts. Only basic evaluation metrics are shown[3] since providing advanced metrics is likely to overwhelm users [1]. The numbers of ground-truth items, often overlooked, indicate potential biases[4]. Future work will evaluate this design with experts and non-experts. The *Extracted Data* tab shows the data schema of the computer vision output. The *Visualization* tab (Fig. 2) shows the computer vision output and the uncertainty due to missing videos, image quality or fish appearance quality. With the *Report* tab users can annotate and share visualizations from the *Visualization* tab.

3. EXPLORING FISH POPULATIONS

The fish population data, including uncertainty metrics, is multidimensional. We reduce their complexity by using simple graphs in multiple views. [7] argues that multiple views introduce additional complexity (context switching) which can be balanced by the consistency between views (display

[1]fish4knowledge.eu, user interface: f4k.project.cwi.nl and [2]

[2]Use of a set of images with manually identified objects to which automatically identified objects are compared.

[3]True Positive, False Positive, False Negative excluding True Negative, thresholds and rates like Precision/Recall.

[4]The fewer the items, the higher the chance of error.

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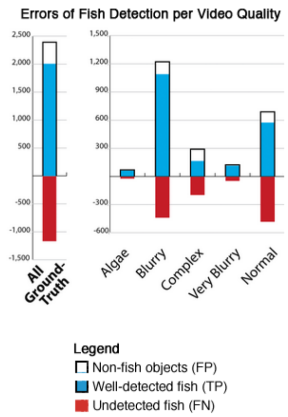

Figure 1: Visualization of uncertainty for non-experts.

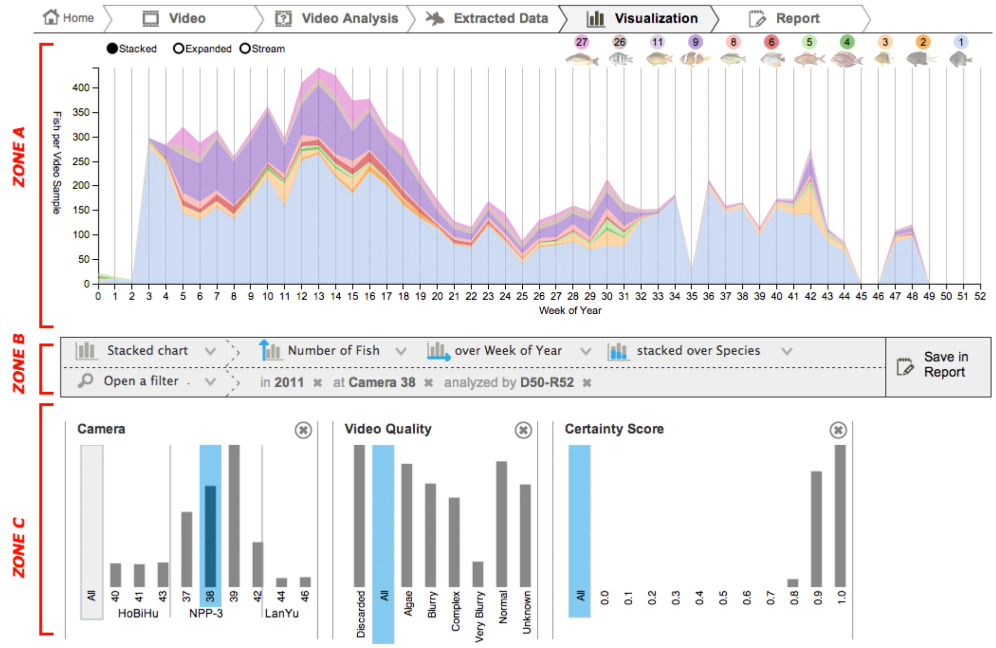

Figure 2: The Visualization tab.

same dataset or same dimensions). Designing views' consistency is subtle: one set of views cannot suit all usages. We propose a design of consistent multiple views for flexible data exploration (Fig. 2). Zone A contains the main graph which is controlled with Zone B: users can select the type of graph (e.g., line chart, box plot, stacked chart) and what data dimension is represented by their axes. E.g., if the Y axis displays numbers of fish, the X axis can be swapped between Day, Camera, Species and other dimensions, to show different fish distributions. The Y axis can also be swapped for numbers of species while keeping the same X axis. Swapping axes is the originality of this design. Users gradually navigates through the dimensions of datasets. Zone C contains display-on-demand filter widgets, one per data dimension, for selecting datasets of interest. It provides histograms for each filterable value. Their Y axis is the same dimension as for Zone A, which ensures multiple views consistency. This design supports both overviewing (Zone C widgets) and detailed views (Zone A main graph). Early user feedback expressed enthusiasm for its high flexibility and intuitiveness: *"I can display anything I want"*. This design is generalizable and was successfully reused in a distinct use case (Fig. 3).

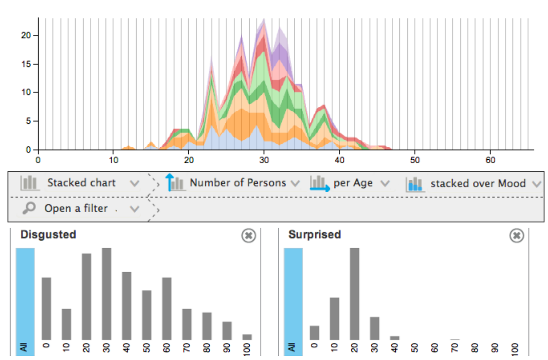

Figure 3: Reuse with emotion recognition data.

4. CONCLUSION

Our interface supports fish population monitoring using computer vision results. It allows preliminary data exploration and identification of uncertainties that may impact further information processing. Early user feedback shows the interface is highly intuitive. Our design is generalizable to other use cases dealing with open-ended multidimensional data exploration, or machine learning uncertainty.

5. REFERENCES

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