Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2017-625-AC2, 2018

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Bathymetry observations of inland water bodies using a tethered single-beam sonar controlled by an Unmanned Aerial Vehicle" *by* Filippo Bandini et al.

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Received and published: 5 March 2018

Response to the review of Anonymous Referee 2. We have copied the comments of the referee hereunder, our comments appear after their comments.

This manuscript presents an innovative approach to the measurement of bathymetry in water bodies using a UAV equipped with a tethered sonar. While the use of ROVs (such as remote control boats) have been used to conduct bathymetry surveys, this is the first time I have seen a UAV used for this approach. This idea to use unmanned vehicles for bathymetry mapping is a simple one, but as shown in this paper, an involved process. The authors describe the method adequately (although sometimes

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very brief), and use two case studies to showcase the results of their work; the results are very encouraging. The method described here is a valuable contribution to the field, as the accuracy of computer models will certainly benefit from the inclusion of the high-resolution bathymetry data provided by using the UAV. I outline my suggestions to the authors for improvement below.

We thank the referee for the feedback and the comments on the article.

General Comments: 1) The paper needs to be proof read thoroughly for English. There are instances ofvery long sentences (especially in the Methods section), which make it very difficult to grasp exactly what the authors are trying to convey without re-reading them several times. The paper will read a lot better after having been edited for the English.

We will provide a revised version of the manuscript which has undergone editing for English language.

2) The figures in text are useful, however I find that they are overall too small, and have text in them that is hard to read. I suggest that the authors make some of the figures larger (e.g, Figs 1, 2, 5, 6, 7, 9), and the text labels on axes etc in all the figures should be larger.

We will increase the size of figure labels in our revision plan.

3) For Figures 6,7,9: The water depth colour scale is very hard to see, as the dots are very small. Also, the intervals of depth are not consistent intervals. I think that for 6, for example, it would be better to depict this as depth between 0-36 m at consistent intervals of 3m (0-3, 3.01-6, etc). For Figure 7, The difference would also be easier to understand if the intervals were of consistent length.

The size of the legend labels and the intervals will be adjusted to improve visualization and consistency.

4) The figure captions are sometimes lacking. I suggest that the authors make sure

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that everything that is shown in figures, including abbreviations and locations, are adequately described in the captions without the reader having to refer back to the text.

Figure captions will be thoroughly revised

5) Most abbreviations used after the intro are defined the wrong way around. E.g., pg 6, line 10: Wsen and Hsens, should be referred to as: "Sensor width and height, denoted Wsens and Hsens, respectively..." or something similar. Also, object distance (OD) is no where defined in text. Please make sure that all abbreviations are spelled out in full and then abbreviated in ().

In our revision we will follow this suggested order: abbreviation are spelled out and then abbreviated in parenthesis and not the other way around. We will define all the abbreviations in text.

Specific comments: 6) pg 2, line 21: who is the manufacturer of the bathymetric depth finder mentioned? The company “Deeper, UAB” (Vilnius, Lithuania). We will rephrased the wording “developed by Deeper, UAB (Vilnius, Lithuania)” with “manufactured by Deeper, UAB (Vilnius, Lithuania)” 7) A quick google search tells me that the model of sonar used in this study is the: Deeper Smart Sensor PRO+ (Deeper, UAB, Vilnius, Lithuania). Please make sure that the model numbers/names for all equipment mentioned in the manuscript are correct and that the manufacturer and their location is in text. This is generally quoted in text as I done in the first line of this specific comment.

We will replace the wording “Deeper Smart Sonar Pro Plus” with ”Deeper Smart Sensor PRO+”. We will try to use also for the other sensors/equipment the model names which appear on the official company website.

8) The methods section would read better if it were restructured. Describing the UAV set up first would make more sense, followed by the sonar instrument used. I found myself wanting more details about the sonar unit (like depth it can measure to) in 2.1, to find that it had been put in 2.3 instead. I would suggest putting 2.2 first, and then

combining sections 2.1 and 2.3 and have them follow the section on the UAV.

We fully agree with this comment and we will change to this structure in our revision plans.

9) General comment: is it a coastline or shore? These are rivers/lakes are they not? To avoid confusion I would refer to it as the shore. Coastline refers to something next to an ocean or sea.

It is “shore” and only the word “shore” will be used.

10) Fig 3, there is some overlap between the axis and the label z. OD is over the line, should be to the side.

We plan to avoid overlapping between lines and labels in the revised version of the manuscript.

11) Hsens isn’t described in the caption. FOV (degree) label is cut off.

We will include all the variables in the caption and we will improve readability of the FOV label.

12) pg 6, lines 10-21: Please define the equation elements more clearly, rather than just mentioning what is in the equation. The sentence lines 13-16 is particularly confusing to follow. Perhaps having the equations in line in text after they are first mentioned would be an easier way to understand and explain what is going on, without having to refer to the table.

Revision plans: remove equation table and put all the equation in text after their explanations. Sentence 13-16 will be split and clarified.

13) pg 8, line 3: please refer to equations 8 and 9 in text here.

This will be done in the revised chapter structure.

14) how long does it take to do all of the data processing? There are a lot of steps,

but an indication of how long it takes to do the data processing would be a useful. Are these scripted codes? Done manually?

All the scripts are coded in MATLAB and the post-processing is autonomous. At the current stage the user input is only required to manually pinpoint the sonar position on the images. But vision navigation-derived algorithms can easily replace the manual input.

15) Fig 8/pg 11, line 12: "underestimation" - are the sonars underestimating or estimating the depth?? The points sit above the line, so they look to me that they are slightly overestimating not underestimating as you say in text. You mention later in text that the sonar systematically overestimates water depth in the channel (pg 13, line 15).

This was a clear typo: the sonar overestimates depth.

16) Table 3: I suggest the authors swap the rows and columns around. So that the data for sample size, RMSE, etc, reads down the column rather than across. This will also help with the formatting of the long names of the comparisons shown; wider first column, and narrower columns for statistics.

We agree and we will include this in our revision.

17) Fig 10 caption: I am assuming that x is the position along the transect, but in which direction with respect to the Lat/Long quoted?

We will change the wording x with “distance from left bank (m)” and provide the exact coordinate of the left bank point.

18) Table 4, LIDAR, column 3: "few dm", is this supposed to be cm?

Lidar footprints generally correspond to the spatial resolution of data. The footprint depends on the LIDAR sensor and on the flight height. There are few bathymetric LIDARs available on the market and their footprint is generally in that order of magnitude (dm-meters). According to Bailly (2010) bathymetric LIDAR footprints delineate areas

of a few square decimetres for the Experimental Airborne Advanced Research LiDAR (EAARL) system (Kinzel et al., 2007), and up to 25 m2 in the SHOALS 1000-T system (Hilldale and Raff, 2007; Millar, 2008). If the referee knows a LIDAR with smaller footprint at common airplane flight heights, we ask to be informed. References:

âĂć Bailly, J. S., le Coarer, Y., Languille, P., Stigermark, C. J. and Allouis, T.: Geostatistical estimations of bathymetric LiDAR errors on rivers, Earth Surf. Process. Landforms, 35(10), 1199–1210, doi:10.1002/esp.1991, 2010.

âĂć Hilldale RC, Raff D. 2007. Assessing the ability of airborne lidar to map river bathymetry. Earth Surface Processes and Landforms 33: (5) 773–783

âĂć Kinzel PJ, Wright CW, Nelson JM, Burman AR. 2007. Evaluation of an experimental lidar for surveying a shallow, braided, sand-bedded river. Journal of Hydraulic Engineering 133: (7) 838–842.

âĂć Millar D. 2008. Using airborne lidar bathymetry to map shallow river environments: A successful pilot on the Colorado River. Geophysical Research Abstracts 10

19) What happens if an operator can't wade into a river to get ground truth measurements?

If the surveyor could not retrieve any in-situ observation as ground truth, the accuracy of the survey would be ca. 3.8

20) Table B1: What currency are the costs quoted in? Also on pg 2, line 37

We noticed that in some cells we forgot to indicate that the units were US dollars. We will mention that the currency is US dollars in the column header.

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