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Interactive comment on "Case-based formalization and reasoning method for knowledge in digital terrain analysis – Illustrated by determining the catchment area threshold for extracting drainage networks" *by* C.-Z. Qin et al.

C.-Z. Qin et al.

qincz@lreis.ac.cn

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The authors thank the anonymous referee for the constructive comments which are helpful for improving the final version of this manuscript. We answer these comments as below.

Comment 1: Authors suggest to replace a deep functional analysis of application context by the method based on learning from various previous solutions regardless of their detailed knowledge. OK, deeper functional analysis can be too difficult and selection of only some elements of application context can be a solution. However selection

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of used attributes and similarity functions was reasoned only poorly and in no way verified.

Response: In this study we explored how to formalize application-context knowledge in DTA and apply it to DTA modeling, when other two types of DTA knowledge (i.e., task knowledge and algorithm knowledge) have been formalized and hence can be used in existing DTA-assisted tools. The method proposed in current study focuses on DTA domain and considers the area and the terrain condition through a few simple attributes for describing the study area characteristics of a DTA application case. We also keep the similarity function on each attribute as a simpler form before more detailed research would be conducted to improve it. Preliminary evaluation results based on a case base prepared from the peer-reviewed papers we manually selected from mainstream journals of related domains show the reasonableness of the proposed case-based method. The design of both the attributes and the similarity calculation methods could be improved to reflect the domain-specific application-context knowledge more efficient, which needs additional research. For example, if the case base is with a large size, a machine learning algorithm would be available for calibrating the parameter-settings for similarity functions automatically. We will revise the manuscript to discuss the research issues in future work.

Comment 2: Presumption that articles published in good journals are supposed to provide good solutions for their specific study areas based on experts' experience and knowledge of the target task can be justified in general, but it is probably too optimistic in some cases even considering that determination of drainage network is probably only marginal problem for a part of articles. So no every solution published in good journal have to be well. And therefore a method based on selection the only one 'exemplary' published solution I feel as problematic.

Response: We agree with the referee that the solutions presented in articles published in good journal might not be optimal. In this study we assumed that those solutions are normally good for their specific study areas based on experts' experience and

knowledge of the target task. We manually selected the peer-reviewed papers related to the drainage network extraction applications which were published in mainstream journals of related domains. By this means the cases used could be kept as accurate (or reliable) as possible. Additional research is needed to enhance the proposed method by taking the reliability of the case into account. Although the solution from the case-based method might not be perfect, the method proposed in this study might automate the DTA modeling process, which makes it easy for users (especially non-expert users), and meanwhile the solution could be reasonable comparatively. This is valuable especially for non-expert users at the beginning of the modeling when field data for evaluation might be not easy to be obtained. We will revise the manuscript to include above discussion.

Comment 3: While the suggested computation of similarity of individual attributes between the new application and published one can be acceptable, the synthesis (computation of 'overall similarity') is more problematic. No (equal) weighting of used attributes is a basic problem. It is very improbable that similarity in name of target task, cell size, area, relief, slope distribution and hypsometric integral will have the same effect on determination of proper catchment area threshold for extracting drainage networks.

Response: In current method proposed, the overall similarity between a case and a new application problem is determined by applying a minimum operator to synthesizing the similarity values on every attributes in a cautious manner. In the geographical domain, a minimum operator based on the limiting factor principle is often used to synthesize similarity values on multiple attributes (Zhu and Band, 1994). This synthesis by a minimum operator means that the overall similarity result is lower (i.e., higher uncertainty for reasoning result) than it from other synthesis means such as weighted-average. Based on the experiment shown in the original manuscript, we also tested the effect of calculating the overall similarity by a simple average operator (a representative of weighted-average) instead of the minimum operator. The evaluation results show that the overall similarity for every case increased and the lowest overall similarity

among results for 50 evaluation cases increased from 0.47 to 0.68 when the minimum operator was replaced by the simple average operator. Among 50 evaluation cases, the solutions for 13 evaluation cases from the proposed method changed because the cases with the highest similarity resulted by the simple average operator were different from those resulted by the minimum operator. Due to the synthesis by the simple average operator instead of the minimum operator, the relative deviation of river density (E) increased for 10 of these 13 evaluation cases with different solutions, when E slightly decreased for other 3 evaluation cases. The increase of E even reached 20∼80 times for some cases with the overall similarity values larger than 0.8. Because the overall similarity values were larger than 0.8 for most of evaluation cases, there is no a reasonable relationship between the overall similarity value and the E. This shows that the proposed method performed poorly when the simple average operator was used instead of the minimum operator. Note that the simple average is the common representative of weighted-average, and currently it is difficult to choose a more complex weighted-average for synthesizing similarity values on multiple attributes. Therefore the synthesis by a minimum operator is proposed for current method in this study. Additional research is needed to evaluate the similarity calculation method through further test with more types of DTA applications. We will revise the manuscript to include above discussion.

Comment 4: Evaluation of experimental results is very problematic. Authors write (23-25, p.13): "Four levels of E were established empirically to reflect the reasonableness level: reasonable ([0,0.1]), acceptable ((0.1,0.25]), questionable ((0.25,0.5]), and unreasonable ((0.5,+1))." It is non committal for me and if authors do not specify this 'empirical establishment' I feel it as fully subjective division. Why the difference in drainage density is unreasonable only exceed 50 %?! It smell by purpose made establishment of intervals to show "that the proposed method performs satisfactorily" (9, p.14).

Response: Four levels of E were established empirically for a summarized discussion

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on the evaluation results in this study. We have realized that it is subjective to say "reasonable" based on this level of E. We will use the "deviation level" intead of "reasonableness level" to analyze the results by the solutions from the proposed method. The manuscript will be revised to avoid the misleading problem from the subjective wording for the E levels. The evaluation results (Table 3 in the manuscript) show that normally the larger the overall similarity value from the proposed method, the less is the relative deviation of river density (E). This means that the proposed method performs reasonablely.

Comment 5: The title of the paper is too complex and not quite clear. A simplification is suitable (e.g. Case-based formalization and reasoning method for digital terrain analysis – determining the catchment area threshold for extracting drainage networks).

Response: Thanks for the referee's suggestion. This manuscript proposes a case-based formalization for DTA application-context knowledge and the corresponding case-based reasoning method. The determination of catchment area threshold for extracting drainage networks was taken as an example to evaluate the proposed method. Therefore, we plan to change the title of the manuscript to be "Case-based knowledge formalization and reasoning method for digital terrain analysis âŤĂ Application to determining the catchment area threshold for extracting drainage networks".

Comment 6: Because equal weight of all attributes the binary attribute 'the name of the target task' exclude (in final comparison) all cases with another name of the target task. What is the reason of such hard limit? How was determined the attribute for particular cases? Names of types and their occurrence should be added for better understanding.

Response: Current method uses the boolean function to calculate the similarity on the nominal attribute "name of target task". This is a strict limit to prevent the proposed method from determining a case to be the solution case for a new application problem with a totally different task. In current experiment, we manually selected the

peer-reviewed papers related to the drainage network extraction applications to prepare the case base. Thus all cases have same name of target task, i.e., drainage network extraction. More detailed research on the classificiation of target task, such as hierarchical classification or fuzzy classification, would be helpful to relax this limit on the attribute “name of target task“, which is a part of future research. We will revise the manuscript to discuss this issue.

Comment 7: Attribute relief - is it one number for the whole area (then it very dependents on area size) or average value computed by what way? (moving window - the size and shape?)

Response: Here it means the total relief of the study area, which is the maximum minus minimum elevation within the study area. We will revise the manuscript to use the term “total relief“ to make it clear. Two cases with similar values of total relief and very different area sizes will have a low overall similatity from the proposed method, because of their low similarity on the area attribute and the overall similairty calculation by a minimum operator. Here the overall similairty calculation by a minimum operator is more effective than that by a weighted-average operator.

Comment 8: Slope is scale dependent variable so distribution of slopes depend on grid size. Using of cumulative frequency distribution solve this problem only partially.

Response: Yes, the slope cumulative frequency was used in this study instead of the slope frequency distribution to describe the slope distribution attribute and relieve the DEM resolution effect. Because of the attribute “cell size“ in the case and and the overall similairty calculation by a minimum operator, two cases with similar slope cumulative frequency and very different cell sizes will have a low overall similarity from the proposed method. We will revise the manuscript to state this point.

Comment 9: Similarity functions seem to be determined subjectively. Why difference in magnitude of cell size (and area) can better reflect the level of similarity between DTA applications than the numerical difference in cell size? Why is used natural log in one

case and common in another? Etc.

Response: The similarity function for each individual attribute was designed empirically to be compatible with the value type of the attribute and in accord with domain knowledge regarding the level of similarity due to the difference in the attribute value between the new application problem and an existing case. Specific to the attribute "cell size", the design of its similarity function is mainly based on two reasons. First, the numerical difference in cell size does not make sense. Taking an application with 10-m resolution as example, another application with a coarser resolution of 25 m is comparable to it from a cell size perspective, while on the other hand the resolution must be larger than 0 m. Secondly, a bell-shaped similarity function for a logarithmic transformation of cell size could balance the decrease of similarity value for those situations with a coarser resolution or a finer resolution. The similarity function for the attribute "area" is designed similarly. Because of the different characteristics of other attributes, their similarity functions are designed to be with different forms. The reason for the design of the similarity function on each attribute will be stated clearly in the revised manuscript.

Comment 10: In regard to aforementioned problems I cannot recommend the paper in the present form, (presented experiment is not enough documented to support the interpretations and conclusions). However, majority of problems could be eliminated by selection of more appropriate method of synthesis. I think, multidimensional regression is a way. This method provide for elimination of inappropriate possible influence of particular problematic published case studies (ii), reveal various weights (suitability) of used attributed and similarity functions (mainly if hierarchical partitioning will be used) (iii) and last but not least alternative results (using various attributes and methods of similarity computation) can be compared to find the most appropriate regression equation. Suitability of selected attributes and methods can be documented by this way (i) and it can partly also substitute problematic way of evaluation in this paper (iv).

Response: In current method, the overall similarity is synthesized by applying a min-

imum operator to the similarity values on every attributes in a cautious manner. It is based on the limiting factor principle and can prevent the proposed method from some unreasonable performance. Please also see our responses above to the seventh and eighth item of comments from anonymous referee #2. Based on the experiment shown in the original manuscript, we also tested the effect of calculating the overall similarity by a simple average operator (a representative of weighted-average) instead of the minimum operator. The expeirmental results show that the proposed method with a minimum operator performs more reasonablely. Please also see our response above to the third item of comments from anonymous referee #2. We will revise the manuscript to include above discussion. Thanks for the referee's suggestion on the multidimensional regression for synthesizing individual similarity values. For a case base with large size, a machine learning algorithm would be available for calibrating the parameter-settings for similarity functions automatically. The size of case base does matter. Considerring that the size of current case based is still comparatively limited when a part of it was used as the set of indenpendent evaluation cases, we think that automatic or semi-automatic methods of creating cases should be developed to speed up the expansion of the case base (not only for the current target task, but also for other DTA application tasks). Subsequently the multidimensional regression and other machine learning methods could be tested for their effectiveness on this issue. We will revise the manuscript to discuss the research issues in future work.

Comment 11: Please also note the supplement to this comment: http://www.hydrol-earth-syst-sci-discuss.net/hess-2015-539/hess-2015-539-RC2-supplement.pdf

Response: Thanks for the referee's detailed comments marked in the original manuscript. For those on syntax errors in the original manuscript, we will revise accordingly. For other marked comments (numbered as Comment 11a∼11j below), the item-by-item responses are listed as follows.

Comment 11a: Page 3, lines 31-32. "the case-based method can simplify knowledge acquisition into case acquisition, with no need for an explicit expression model of do-

main knowledge" – and it is a problem.

Response: We will revise this sentence as follow to avoid misleading. Compared with traditional rule-based knowledge representation and reasoning methods, the case-based method transforms knowledge acquisition into case acquisition, with no need for an explicit expression of domain knowledge. Therefore the case-based method is suitable for DTA application-context knowledge which is non-systematic and largely tacit knowledge.

Comment 11b: Page 5, lines 25-27. "The optional output part of the case-based formalization does not currently need to be considered for the DTA domain because normally there is no change in the application context of a DTA application case when the DTA model is applied." – ?

Response: We will revise this sentence as follow to avoid confusing. The output part of a case, which is optional in the case-based formalization (Kolodner, 1993), is set to be null in this study because normally there is no change in the application context of a DTA application problem when the solution of this case is applied to this application problem.

Comment 11c: Page 6, lines 2-3. "The solution of the case with the highest similarity is reused for the new DTA application problem" – why?

Response: The case with the highest similarity means it with the most similar application context cosiderred. According to the case-based reasoning principle that solutions for similar problems are often similar, the solution of the case with the highest similarity is reused for the new DTA application problem. We will revise the manuscript to state it clearly.

Comment 11d: Page 10, lines 4-5. "the difference in magnitude of cell size can better reflect the level of similarity between DTA applications than the numerical difference in cell size." – why?

Response: Please see our response above to the 9th item (on the design of the similarity function on cell size) of comments from anonymous referee #2.

Comment 11e: Page 11, lines 21-23. That means all attributes are considered as equally significant and limiting. This assumption is not supported by any arguments.

Response: In current method, the overall similarity is synthesized by applying a minimum operator to the similarity values on every attributes in a cautious manner. It is based on the limiting factor principle and is often used to synthesize similarity values on multiple attributes in the geographical domain (Zhu and Band, 1994). We also tested the effect of calculating the overall similarity by a simple average operator (a representative of weighted-average) instead of the minimum operator. The expeirmental results show that the proposed method with a minimum operator performs more reasonablely. Please also see our response above to the third item of comments from anonymous referee #2. We will revise the manuscript to make a fruther discussion on it.

Comment 11f: Page 12, lines 26-27. "These articles are supposed to provide good solutions for their specific study areas based on experts' experience and knowledge of the target task" – really?

Response: In this study we assumed that the solutions presented in articles published in mainstream journals of related domains are normally good (might not be optimal) for their specific study areas based on experts' experience and knowledge of the target task. We manually selected the peer-reviewed papers related to the drainage network extraction applications which were published in mainstream journals of related domains. By this means the cases used could be kept as accurate (or reliable) as possible. Please also see our response above to the second item of comments from anonymous referee #2. We will revise the manuscript to avoid misleanding.

Comment 11g: Page 13, line 16. "the relative error of river density" – Is it really error? Only if we suppose a perfect settings of CA thresholds in all studies (that is unjustified presumption). Moreover, why river density and no directly CA thershold was used for

definition of the 'error'?

Response: We will revise the manuscript to use the term "relative deviation of river density" instead of the relative error of river density to avoid misleading. The deviations between the CA threshold values for different cases are highly varied (about 10-3 ∼103 km2). Therefore the relative deviation of river density was used as an index for comparison between the results for different application problems and quantitative evaluation of the proposed method. We will revise the manuscript to state this point.

Comment 11h: Page 20. The similarity function on the relief attribute – ?

Response: In this study the attribute "relief" means the total relief of the study area. We will revise the manuscript to use the term "total relief" and also precisely define the calculation of the total relief, i.e., the maximum minus minimum elevation within the study area. As the description in Section 4.2.4 in the original manuscript, the similarity function for the total relief attribute was designed as a linear function using the absolute difference between the total relief of the new DTA application problem and that of existing case. Corresponding to a zero similarity value, the maximum difference between two total relief values is the larger of the total relief differences between the new application problem values and each of two extreme cases (a flat area with a total relief of zero, and an area with relief from the 8848 m of Mount Everest to sea level). So is the similarity function for the total relief attribute shown in Table 2.

Comment 11i: Page 20. The similarity function on the hypsometric curve – ?mistake

Response: Here is no mistake. The design of the similarity function for the attribute "hypsometric curve" is based on the hypsometric integral (HI). The form of the function is similar to that of the total relief attribute. The similarity on HI is 0 for the maximum possible deviation from the HI of the new application problem. So is the similarity function for this attribute shown in Table 2. Please see Section 4.2.6 in the manuscript for the description on this design.

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