EVALUATION OF THE DIPLOMA THESIS "PROBABILISTIC MODEL FOR LAND COVER TYPE RECOGNITION IN TEMPORAL SEQUENCES OF SATELLITE IMAGES" BY MARTIN SPANEL

The thesis considers the task of segmenting temporal sequences of satellite data for particular geo-locations w.r.t. land cover type and related detection of changes thereof. It proposes three different probabilistic models and corresponding learning approaches for their respective parameters. The learning approaches have to cope with partially missing data (cloud occlusion) and partial annotations. The latter are given for some subset of particular dates only.

The first proposed model combines a class agnostic breakpoint detection with a subsequent classification of the intervals between the breakpoints. The signals between the breakpoints are modelled as a combination of a linear trend and a periodic seasonal component. The classifier is a simple k-nearest neighbours classifier on the regression model parameters. The results of the approach are verified in terms of consistency with the partial annotations.

The second approach models contiguous signal sequences by Hidden Markov Models (HMM) for the corresponding land cover classes. It seeks the a-posteriori most probable segmentation of an sequence in terms of the class specific HMMs. The training data for the HMMs are acquired from validated inference results obtained from the regression model.

Finally, a third model utilises a bi-directional recurrent neural network with Gated Recurrent Units (GRU). It is learned on the same training data as the HMM based model, but without explicit omission of the missing data.

All three models are learned and verified on spatio-temporal data of a patch in the national park Sumava acquired from Landsat satellites over a period of 15 years. The annotations are provided by an expert based on triennial geo-referenced airborne RGB images.

Thesis strengths. The author considered and implemented three different approaches with increasing model complexity for the considered task. The problem with partial annotations has been solved by using results obtained by the baseline method (class agnostic breakpoint detection), validating them and using the validated part as training data for the advanced models. The author has considered different ways for dealing with the issue of missing data and proposed variants suitable for each of the considered models.

Thesis weaknesses. A section summarising existing approaches and the state of the art is missing. Instead, the author has interspersed corresponding short remarks and citations in the main body of the thesis. The clarity of presentation in some parts of the thesis can be improved. The same holds for language correctness. Some model and implementation details are missing, as e.g. the type of appearance model used in the HMMs.

The thesis has in my view a few conceptual weaknesses.

- In the case of generative probabilistic models the author not always distinguishes correctly between the learning objective and the loss used for inference.

Date: May 29, 2019.

- In the case of the HMM based model the author simply drops the missing data (including the hidden states). Whereas this is conceptually correct for the baseline model, here there is a better way: dropping the emission terms in the HMM model without dropping the transition terms would be correct.
- The author considers the MAP decision for the HMM based model, without discussing other options for the loss function. I would have expected at least a discussion of a Hamming distance based loss (as it is used for the recurrent network).

Questions for the defence. Besides the questions arising from the previously mentioned conceptual weaknesses, I suggest the following additional questions for the defence.

- What are the learning objectives and the losses used for the inference for each of the three proposed approaches?
- Explain the definition of "total accuracy" (Sec. 3..4.1). How is it related to the used inference loss?

Overall evaluation. In my opinion, Martin Spanel approached the task in a highly motivated, focussed and diligent way. He showed good knowledge of concepts, algorithms and the ability to implement them. The methods he designed and implemented will certainly contribute to an ongoing project funded by the European Space Agency. In my opinion these strengths compensate partially for the mentioned weaknesses of the thesis. I recommend to accept the thesis and evaluate it with the grade B.

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