Problem

We need a meta learner which would evolve with each video, tag set provided by the user. The problem is closely related to multi-label classification problem in unsupervised settings.
The final aim of learner would be to classify the video based on feature set into a class consisting of different labels. Below are summary from few of papers which involve algorithms/models which may be useful in our setting.

Consensus Learning

Consensus learning considers the problem of consolidating multiple supervised and unsupervised information sources by negotiating their predictions to form a superior classification solution. Thus we do not need training or test data for the reaching the consensus.

The paper *"Heterogeneous Source Consensus Learning via Decision Propagation and Negotiation"* achieves this form of consolidation on multi class classification. We could use ideas from this for multi-label classification.

In the problem taken by this paper we have λ^a as different base classifiers / clustering models. $T = \{x_1, x_2, ...\}$ as object set for which prediction needs to be done. For each x a label $y \in \{1, 2, .., c\}$ is to be predicted such that there is maximum consensus between the base classifiers.
The solution is obtained in two steps :-

1. $P(y|x, \lambda^a)$, probability of x belonging to class y according to one to the models λ^a. This represents global consensus and is computed using label information propagation in belief graph the paper describes.
   The belief graph has nodes n represented by conditional probability vector $(v_1, v_2..v_c)$, where v_i denoted probability that $y = i$ if $x \in n^{th}$ node.
2. Second thing is $P(\lambda^a|x)$ the local weight on λ^a which is proportional to prediction accuracy on λ^a on x.
   This represents local consensus.

Then $P(y|x, E) = \sum_{a=1}^{r} P(y|x, \lambda^a)P(\lambda^a|x)$ represent the consensus.
The predicted label is $\hat{y} = argmax_y P(y|x, E)$. The algorithms mentioned in the paper to computed these results appear sound.

Difference of consensus learning from problem at hand

Here are few concerns we would like to address -

1. Our problem involves multi label classification. We need to adapt this method if to be used for multilabel case. Came across this paper - *"Multilabel Consensus*

Classification" by same authors. Will thoroughly study the paper and provide details later.

2. Adaptation of above technique would lead us to assume each player in game is a base classifier λ^a and proceed. But we would not have classification for each $x \in T$ from all λ^a. So consensus learning in sparse conditions needed.

3. Current algorithm does not describe how to update the parameters if a new base classifier λ is added to model. In sparse setting need to handle how to update parameters when a new (x, y) pair is given by user. This is desirable as our data comes from when players tag a given video at different time steps.

If above issues are handled then the consensus learning appears to be quite good for the problem we have. Will work to see how much of these is feasible.

Boosting kind of Meta learners

As we have seen earlier we need an online boosting kind of framework for our problems. Paper title *"Online Bagging and Boosting"* does online ADABOOST. Here a sequence of base models $h_1, h_2, ...h_M$ are trained using weighted training sets. In online framework each base model has training set consisting of K copies of each of original training examples where $P(K = k) = \frac{N}{k}\frac{1}{N}^k(1 - \frac{1}{N})^{N-k}$ which is binomial. As $N \Rightarrow$ inf distribution of K becomes poisson.
The poisson parameter λ if misclassified is increased otherwise decreased when presented to next base model.

In our problem we have following concerns :

1. The boosting learners require training data with true labels. May be we could generate initial training data to initialize the learner

2. We could treat each of our players as base learners and model them using the inputs we receive from them. Then use ADABOOST over them. But the data is sparse so need some other online algorithm like LPBOOST. Need to thoroughly study paper - *"Online Multi-Class LPBOOST"* to look for motivations.

3. The tag set we obtain from users are noisy and do not represent true label set. Need to account for that.

4. Boosting/ensemble learners exist for multilabel classification. Need to look into them and adapt them to unsupervised online settings.

5. Other possibility could be use some static base learners like image classifiers, audio/metadata based classifiers and make adaboost metalearner using them. Then evolve this learner using the input from users. I have not given much thought on this.

Boosting / Bagging based methods are also popular for multi label classification above concerns are valid.

Including Knowledge Graph

As we are building the knowledge graph directions related to using knowledge graph to capture relation among labels should be explored.

Another area related for good performance of metalearner is section of feature set. Need to look into papers which improve performance using improvement/change of features used for training/testing.

Current Direction

Currently I am looking into multi-label consensus learning. Will look into LPBoosting for sparse data motivations. Also need to look into feature set selection.

References

[1] Jing Gaoy,Wei Fanz,Yizhou Suny,and Jiawei Hany *Heterogeneous Source Consensus Learning via Decision Propagation and Negotiation.*

[2] Nikunj C Ojha, Stuart Russel *Online Bagging and Boosting*