**Third International Conference on IFS, Sofia, 16-17 Oct. 1999**
**NIFS 5 (1999) 4, 48-50**

# INTUITIONISTIC FUZZY SET USE FOR TRAINING NEURAL NETS

**Valentina V. Radeva**
**CLBME - Bulg. Academy of Sci., 105 Bl., Acad. G. Bonchev Str., Sofia-1113, Bulgaria**

Using neural nets for the purpose of classification is not a new task for people working in the field of Artificial Intelligence. One of the most popular and a kind of book-examples is recognition of the characters of the alphabet - transformation from a set of black and white pixels to an ASCII character. During the training the input image is mapped to the output ASCII character. Let $S(A)$ be the set of all black pixels belonging to the image of character $A$ and $S(\#)$ be the set of all black pixels belonging to the image of character $\#$, where $\# = (A, ..., Z, a, ..., z, 0, ..., 9)$. Let assume that all black pixels have one and the same size and bidimentional coordinates. Let $c(\#jx, \#jy)$ be the representation of the $x$ and $y$ coordinate of the pixel $j$ of the image $S(\#)$ and $C(\#x, \#y)$ be the set of coordinates of all pixels belonging to $S(\#)$, where $\# = (A, ..., Z, a, ..., z, 0, ..., 9)$.

The training set can be represented as a set of elements of the following type: $(S(\#), R(\#))$. Where $R(\#)$ is the corresponding result of the work of the neural net when the image of the $\#$ $(S(\#))$ is entered to the input of the neural net, where $\# = (A, ..., Z, a, ..., z, 0, ..., 9)$.

Using such kind of training set the neural net is trained to do mapping between the input element and the corresponding output value. The classic backpropagation training algorithm described by Werbos from 1974 can be used for this training if the intersection of the subsets $S(\#)$ is the empty set and the intersection of the corresponding outputs $R(\#)$ is the empty set, where $\# = (A, ..., Z, a, ..., z, 0, ..., 9)$. Concerning real data classification it is possible to find elements that can not be strictly related to only one classifications type. The input subsets do intersect, but not the output. In the standard training (backpropagation or not, with or without a teacher) this intersections of the input subsets, without corresponding overlapping in the values of the output result would lead to endless training without gaining satisfastory results.

Let $S(A_i)$ be the set of all black pixels belonging to the $i$ possible representation image of character $A$; $S(\#i)$ be the set of all black pixels belonging to the $i$ possible representation image of character $\#$, where $\# = (A, ..., Z, a, ..., z, 0, ..., 9)$ In reality i could be unlimited (for example handwriting) but here we will consider $i = (1...n)$, where limit n which is a big enough number. Let $c(\#ijx, \#ijy)$ be the representation of the $x$ and $y$ coordinate of the pixel $j$ of the image $S(\#i)$ and $C(\#ix, \#iy)$ be the set of coordinates of all pixels belonging to $S(\#i)$, where $\# = (A, ..., Z, a, ..., z, 0, ..., 9)$. Let $T$ be the training set, $S^*$ be the representation of all the input elements of the training set and $R^*$ be be the representation of all the output elements of the training set.

$$S^* = \cup(S(\#))$$

$$R^* = \cup(R(\#))$$

$$T = (S^*, R^*)$$

where $\# = (A, ..., Z, a, ..., z, 0, ..., 9)$.

Let the intersection of the subsets $S(\#)$ is NOT the empty set and the intersection of the corresponding outputs $R(\#)$ is the empty set, where $\# = (A, ..., Z, a, ..., z, 0, ..., 9)$. For one and the same data (image) we want to have different output values.

The methods of the classic neural net training can not overcome the situation described above. For every representation of the one of the "contradictory" elements a change in the weights of the neural net will be made and the neural net will be trained to recognize the input image as concrete output value. When the next of elements is represented to the input of the Neural Net it will recognize it as this concrete output value, but the classic method of training will detect an error and new changing of weights will be preformed and the results of the previous training will be destroyed.

The solution is based on deviding the input set to Intuitionistic Fuzzy Sets (IFSs) [1] and fuzzy interpretation of the output results during the training of the Neural Net. The elements from the intersection of the subsets are treated in a new, different way.

Let redefine the subset $S(\#)$ to the following IF-sub-subsets, according to intersection of $S(\#)$ with the other subsets from $S^*$. Let $Smue(\#)$ be the IF-sub-subset of all representations of the image of the character $\#$ ($\# = (A, ..., Z, a, ..., z, 0, ..., 9)$) which do not have analog in other subsets of $S^*$. These are the images that belong only to the $S(\#)$ subset.

Let $Sro(\#)$ be the IF-sub-subset of all representations of the image of the character $\#$ ($\# = (A, ..., Z, a, ..., z, 0, ..., 9)$) which have analog in other subsets of $S^*$. These are the images that could belong to the $S(\#)$ subset but could belong to another subset from $S^*$. Let $RO(\#)$ be the set of alternative subset for these representations of the image of the character $\#$ ($\# = (A, ..., Z, a, ..., z, 0, ..., 9)$).

Let $Seta(\#)$ be the IF-sub-subset of all images of the character $\#$ $(\# = (A, ..., Z, a, ..., z, 0, ..., 9))$ which do not belong to $S(\#)$.

$$Seta(\#) = S^* - Smue(\#) - Sro(\#).$$

These are the images that belong to all the other subsets from $S^*$. The training IFS will have a new representation: for each $Smue(\#) \rightarrow R(\#)$ and For each $Sro(\#) \rightarrow (or)R(RO(\#))$ where $\#$ $(\# = (A, ..., Z, a, ..., z, 0, ..., 9))$.

If neural net processing of the element of $Smue(\#)$ is the output value of $R(\#)$ the training will be considered as successful. Else - corrections has to be made using the classic algorithms.

If neural net processing of the element of $Sro(\#)$ is the output value, valid for of any of the $R(\&)$, where $\&$ are the subsets belonging to $RO(\#)$ the training will be considered as successful. Else corrections will be made using the classic algorithms on the base of $R(\#)$. This method assures the end of the training in all cases.

When the trained neural net is used for classification the output value can be evaluated by the means of fussy interpretation based on statistics or in the classic manner.

**Reference:**

[1] K. Atanassov, *Intuitionistic fuzzy sets,*Fuzzy sets and Systems, Vol. 20, 1986, No. 1, 87-96.