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Title of Thesis: **Enhanced Image Identification Using Extended Fuzzy Logic**

SUMMARY

All crimes hit mankind hard. CCTV camera undoubtedly is a well-established tool for capturing the face of the criminal at the crime site. Sometimes the footage of CCTV is not available, either due to the non-functionality of camera or, it may not be possible to install it everywhere, particularly in the developing countries. In this work, we are focusing on the problem of identification of the facial image on the basis of description given by onlooker(s). Forensic experts have to draw the face sketch of the criminal on the basis of onlooker(s) statements. But, unfortunately, with an increasing rate of crimes, we need to automate the process of "Sketching With Word" (SWW). The main objective of this work is to lay the foundation and trigger further discussion on the development of methods for defining as well as estimating fuzzy validity (*f*-validity) of imprecise images for forensic investigation services. For this purpose, the face sketch identification system has been developed in a preliminary form.

The proposed work is based on a technique called SWW. The key reason for applying the proposed technique is that the onlooker has to give statements about different parts of face of a criminal like forehead, eyes, nose, and chin etc. e.g. "His nose was small and chin was long" is used for sketch making. It is difficult to infer the perception of different human brains precisely.

In *f*-geometry imprecise geometric shapes are drawn by spray pen and without making use of rulers and compass. Hence we have used the concept of *f*-geometry for SWW. The *f*-geometry of Zadeh is an example of Unprecisiated Fuzzy Logic (Flu.) When precise reasoning is infeasible, excessively costly or unneeded, the only mode of reasoning which then is admissible is fuzzy valid (*f*-valid) reasoning. The *f*-valid reasoning falls in the province of FLu. Extended Fuzzy Logic (FLe) is the result of adding Unprecisiated Fuzzy Logic with Fuzzy Logic (FL). Face sketch experts have to draw the face of criminals with free hands. The fuzzy geometry is supposed to be the counterpart of Euclidean geometry or

crisp geometry. The fuzzy transformation of Euclidean geometric objects like line, similar side, similar angle, semicircle, circle, triangle, and quadrilateral results in fuzzy version referred as fuzzy line, fuzzy semicircle, fuzzy circle, fuzzy triangle, and fuzzy quadrilateral, respectively. We have standardized the definition of these fuzzy objects (*f*-objects) and computed their membership values by using appropriate membership function. The need for proper aggregation of the multiple features of fuzzy quadrilateral has encouraged us to shift to Ordered Weighted Aggregation (OWA) model. The *f*-validity and fuzzy similarity (*f*-similarity) are the measures of validity and similarity of *f*-objects respectively. Further we have transformed some of the crisp theorems for parallelogram and rhombus into their fuzzy version. Nonetheless, we have employed OWA for estimating both *f*-validity and *f*-similarity among a set of fuzzy triangles, fuzzy parallelogram and fuzzy rhombus.

SWW is basically an extension to the CWW in the imaging domain. CWW is the essential model of perception-based rational decisions in an environment of ambiguity, doubt, and inexactness. For example the statement “His nose were not very large” has perception about the size of nose of a person. In this statement there is doubt about the rationality in the decision taken by onlooker. Hence we have used the concepts from CWW, viz. Generalized Constraint Language (GCL) and Possiblistic Constraints for anticipating the effect of uncertainty. The idea of GCL is used for representing the natural language statement into Possiblistic constraints. The parametric representation of linguistic hedges of fuzzy logic is used for generating membership values for ‘small’, ‘medium’, and ‘large’ constraints on different parts of face.

We have considered a nose having triangular shape consists of three fuzzy lines, sum of internal angles, and length of nose. For aggregation of these five parameters the OWA models like Maximum Entropy, Minimal Variability, Chi Square, Least Square Deviation, and Minimizing Distance from Extreme Point have been used. The results show that the membership values of noses generated by Maximum Entropy and Minimizing Distance from Extreme Point models are closer to degree of OR-ness than other models. On the basis of proposed work, other types of noses as well as rest of the parts face of can be defined.

SWW may provide a scientific basis for human face recognition system by simulating the forensic sketch expert in the discipline of computational forensics. Identification of face sketch of criminal on the basis of onlooker’s statement may open door for identification of imprecise image by using FLe.