The world of manufacturing was experiencing an unprecedented transformation by the 1990s, owing to rapidly changing customer attitudes and globalization of manufacture. Increasingly affluent consumers had started demanding greater product variety. This meant that production runs had to become smaller and the pace of product innovation had to pick up by an order of magnitude. In addition to productivity and quality, time-to-market became an important competitive weapon. In response to these challenges, many technologies have come up and one such technology is Rapid Prototyping Technology (RPT). It is to quickly fabricate physical models, functional prototypes and small batches of parts directly from Computer Aided Design (CAD) data.

Among many known methods of Rapid Prototyping (RP), the Fused Deposition Modeling (FDM) is one of the most widely used techniques in the present scenario. It fabricates parts by extruding molten thermoplastic material or wax through a small nozzle to form a thin bead or road that is deposited in a predetermined pattern to complete each build layer, bonding the extrudate to adjacent and previously deposited roads.
As RP is moving towards rapid manufacturing, there is an increasing demand on obtaining required surface quality parts and minimum post-processing requirements. Structural integrity of the components made by RPT is defined in terms of porosity, surface roughness, dimensional and form accuracies of the components. Surface roughness is highly important in the field of rapid manufacturing and it is mainly dependent on material and process parameters. Porosity also affects both the structural and surface quality of the component. The dimensional accuracy is affected by the two aspects such as expansion and shrinkage of the prototype produced. Hence, there is a need for carrying out studies on parametric influences on the surface integrity of the RP products.

Fused deposition modeling technique is a complex technology involving many different process parameters such as slice thickness, road width, liquefier temperature and air gap whose interactions among them and their influences on the components are yet to be explored. Hence, these process parameters were selected for experimentation and evaluating the structural integrity in terms of porosity, surface roughness and dimensional accuracy in terms of reduction in width and deviation in thickness of the rapid prototypes.

Multiple variable regression method has been used to develop the empirical models which are known as “Response Surface Models (RSM)”. These models could explain the relationship and the interactions of the process parameters such as slice thickness, road width, liquefier temperature and air gap
on surface quality and integrity of rapid prototypes and could predict the same. Artificial Neural Network (ANN) models were developed using back propagation algorithm to predict the responses such as porosity, surface roughness, and dimensional accuracy in terms of reduction in width and deviation in thickness of the RP components.

In this research work, an efficient evolutionary programming for the purpose of simulation has been used for optimizing the process parameters of FDM process. The developed mathematical and neural network models have been combined into two fitness functions and used in evolutionary programming to find out the optimal set of process parameters and predict the corresponding surface integrity characteristics. Except for the few cases, the experimental results have close proximity to the predicted value and hence the model can be validated. Scanning electron microscopic analysis was also carried out to visualize the parametric influences on structural defects.

Simulation optimization with evolutionary programming has been successfully implemented to optimize the process parameters for FDM process. The optimized process parameters evolved in this research work will help to achieve better integrity of the RP components.