Chapter 7

Conclusions

7.1 Discussion

During the last years, the evolution of realistic animation of virtual characters has been tackled from two directions of research. The first one involves facial animation, skin models, and realistic appearance relative to hair or clothing. The second one explores the movement of human characters. In addition to realistic appearance, a virtual human should exhibit realistic movements.

At the present time, the latter is a challenging and still unresolved research topic. As reviewed in chapter 2, dynamic techniques produce realistic motion but they lack of interactive rates. Techniques based on kinematics are able to produce interactive animations but they usually do not provide realistic features to generated animations or postures.

Our Inverse Kinematics framework evaluates a physiological factor such as muscular fatigue at joint level, then introducing a temporal dimension in the convergence to the goal/s and also adding realism to the generated posture. The possibility of using several constraints and ordering them by priority, has allowed us to enforce the importance of some constraints (i.e. balance) next to others (i.e. position constraints).

We have designed and implemented a fatigue model not at individual muscular level but at joint level exploiting antagonistic muscular groups. Our contribution is a generic model that can be applied to different muscular groups of the human body. A new concept has been presented, the half-joint pair. It reflect muscles behavior splitting a single joint in a pair of half-joints where each joint represents a different (agonist/antagonist) muscle group.

The fatigue model has been validated in an Inverse Kinematics framework for realistic posture generation. During the simulation, joints fatigue values are updated so that the system reacts when unbearable fatigue values are reached. The fatigued posture is then adjusted searching for a less fatigued one.

The model has also been exploited for reachable space generation and posture characterization. Reachable spaces and fatigue data are visually presented describing how fatiguing the posture adopted to do the reaching is.

The lack of data relative to muscular strength curves in the ergonomic and biomechanics literature has been a strong barrier in our research. In consequence, the model has been validated in case studies for which data were available. Although strength data used in this research were collected under isometric conditions, we have applied them to slowly evolving postures, that is, in quasi-static conditions. Another barrier found when dealing with articulated structures is the loss of mobility when singular configurations occur. The Inverse Kinematic engine used in our system manages singularities by means of the Singular Value Decomposition of the Jacobian Matrix.

To summarize, we can conclude that the main contributions of our research are the following:

- We have designed a human fatigue model at joint level for slowly evolving postures. Contributions of the model are the reduced number of parameters used and the consideration of the pass of time in the model.
- We have introduced a new concept, the half-joint pair, which let us model the behavior of antagonistic muscle groups.
- We have provided an Inverse Kinematics framework where fatigue is exploited at two differentiated levels. At a low level of optimization, we adjust fatigued

postures. At a higher level, we characterize reachable spaces and postures adopted when doing reaching tasks.

- From the experiment performed we can conclude that the strategy followed by the subjects to decrease fatigue or to find recovery is similar to the one generated by our simulations. Thus, there is good evidence that we have found a workable algorithm to propose postural changes which drive to less fatigued postures. The finding of our research suggests that fatigue data can be effectively used in posture generation and characterization.

7.2 Future Work

This research aimed at solving several issues, some of them are contributions of our work and other are left for future work.

Our research topic is multidisciplinary. It can benefit from results or harm due to the lack of data in diverse areas of research not directly related to computers. The incorporation of a broader set of data relative to muscular strength and passive joint torque may improve results and extend its applicability.

The virtual human used in this research is simplified in several aspects. A more detailed one would help to improve the realism of generated postures.

Collision detection, in particular self-collisions in virtual humans, are essential for a complete animation. Our system could be extended with the integration of a collision model.

Another interesting research issue would be the extension from slowly evolving postures to a dynamic case. Under fatigued conditions, we also could take advantage of the environment to have rest. For example, when arm joints are too fatigued, a postural change could find rest in objects in the scene, a table, a chair, etc. An interesting case study would be elderly people getting into a car.

The consideration of dynamic constraints with dynamic properties such us priority, would help to achieve complex postures.

The study of reachable spaces and fatigue data could be extended to environments with obstacles. In this case, collision detection during reaching tasks should also be managed [Kal03].

Further research on passive torque at joint limits would give more insight on slouch poses continually adopted by people. It could be used in virtual crowds (people waiting the bus, people conversing, etc.)