A Tool for the Evaluation of 3D Kinematics of Newborns at Risk

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Abstract

Quantitative analysis can help to improve the comprehension of human movements and their underlying control mechanisms. Furthermore it has been shown that certain characteristic movements are an indicator for the status of the central nervous system of newborns. This article introduces a tool which enables a detailed visualization and quantification of infant movements. Movements recorded with an electromagnetic tracking system can be transformed in order to reveal subtle movement features. The presented tool can be used to acquire a better understanding of infant movements and identify prognostic markers for neurologic impairments.

Keywords:

Human movement analysis, Data visualization

Methods

Infant motions were recorded with an electromagnetic tracking system. The infant could move arbitrarily lying on its back. Physicians diagnosed each recording either as normal or abnormal depending on whether or not it exhibited “fidgety movements”. These movements of “small amplitude, moderate speed, and variable acceleration” are clinically relevant because their absence is highly correlated with cerebral palsy at a later stage. Limb movements can be derived from the recorded sensor movements using a biomechanical model, i.e. every tracked limb or segment is associated with a time-varying orientation and position in a global reference frame. Movements of a kinematic chain such as the arm or the leg can be represented as trajectories in space created by their endpoint. In order to represent fine movements created by only a part of the kinematic chain, the tracked point can be transformed into the reference system of a segment. E.g., the tip of the hand in the global reference frame can be transformed into the reference system of the upper arm.

Results

Figure 1 shows a working example of how subtle differences in movement quality can be revealed. (A) depicts the trajectory of a child showing fidgety movements. The velocity (color coded) continuously changes from slow to fast and there are lots of changes in direction which result in curvy movements and loops. Since the movements of interest - the fidgety movements - are fine movements which may be superimposed by the movements of the upper arm, the right part (B) of the figure shows the trajectory transformed into the reference system of the upper arm. It is noticeable that the trajectory keeps its curvy properties: the arrows mark parts of the trajectory where it shows smooth changes of direction. (C) depicts the trajectory of an infant showing no fidgety movements. In the global frame it does not reveal big differences to (A). In contrast, (D) showing the movements in the reference frame of the upper arm appears very differently compared to (B). The arrows mark quite abrupt changes in direction which can be seen as sharp kinks. The gradual changes in direction are gone. This corresponds with the finding of the physicians that they could not observe the fine fidgety movements at this newborn.

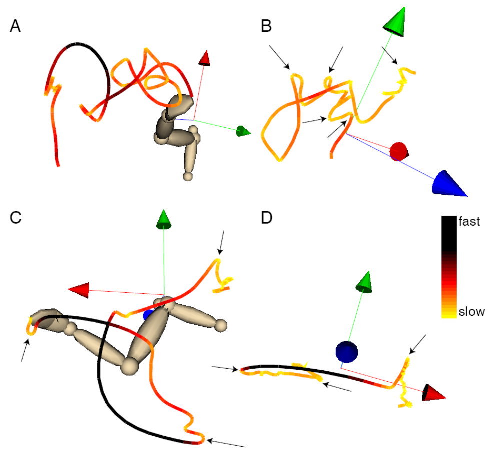

Figure 1- Movement trajectories of one child showing typical fidgety movements (A and B) and of one child showing no fidgety movements (C and D)

Conclusion

We presented a tool which enables quantification and analysis of movements of newborns and demonstrated that it is suitable to reveal subtle differences in movement quality.