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【論文の内容の要旨】

The aging society has become a serious issue in the world. In order to extend healthy life expectancy of elderly people, physical exercise is one of the most important solutions to prevent the decline of physical functions. In fact, elderly people also try to build a small size of community to conduct physical exercise in a friendly way by themselves. However, the contents of typical physical exercises are too monotonous for elderly people to maintain their motivation for practicing frequently. Furthermore, elderly people cannot continue physical exercises because they cannot understand the effect of physical exercises. Exertainment, which means the combination of exercise and entertainment, represents for a form of exercise that includes aspects of entertainment, especially exergaming by game machines. Although full-body exercises can prevent muscle disorders, most of exercising games measure only user's hand motions by accelerometers. Therefore, it is very important to measure human full-body postures significant for physical exercise. Furthermore, most of elderly people are not interested in game machines. On the other hand, since the number of elderly people using the reasonable price of smart phones is increasing in recent years, the introduction of smart phones to elderly people can be an alternative efficient solution to realize exertainment in a local community.

In this thesis, I focus on human posture estimation in the exertainment for elderly people using smart devices. Various types of human posture estimation methods have been proposed so far, but most of them estimate human joint positions, not joint angles. Furthermore, the computational cost of most previous methods is very expensive for inexpensive smart phones. Evolutionary robot vision is one of efficient human posture estimation methods with effective computational cost, but there are still several ill-posed problems such as occlusions and singular postures which are unmeasurable. In order to improve the estimation performance of human postures, I propose multi-view evolutionary robot vision by using multiple smart devices. First, I propose a method for estimating three-dimensional rotational joint angel of human postures from two-dimensional human motion measurement results. Next, I propose an evolutionary strategy for estimating the internal parameters by obtaining correct corresponding points in multi-view in order to improve the estimation performance of human postures. Finally, I develop an exertainment system based on human posture estimation, and show the effectiveness of the proposed method through various types of experiments on exertainment.

The thesis is organized as 6 chapters

Chapter 1 introduces the social and theoretic background the current issues. Next, the contribution and structure of this dissertation are explained.

Chapter 2 explains the concept and current state of exertainment and the theory and methodology of computer vision, and clarifies the goal of this thesis and the importance of human motion analysis in exertainment.

In Chapter 3, I explain several estimation methods of joint angles of human posture proposed in this study, and discuss the estimation performance of evolutionary robot vision between RGB-D camera and monocular camera. First, I propose a method for estimating human postures by growing neural gas and evolutionary algorithm from the point cloud measured by a RGB-D camera. Next, I propose another method for estimating human postures by particle swarm optimization to reduce the computational cost. Furthermore, I propose a method for estimating human postures by evolutionary algorithms with a monocular camera. I compare the performance of the proposed method with conventional methods. Experimental results show that the performance obtained by the monocular camera is almost the same as that of other methods, but the computational cost of the proposed human posture estimation by monocular camera is the lowest among them.

In chapter 4, I propose multi-view evolutionary robot vision for the human posture estimation. First, I propose a method of evolutionary strategy sample consensus

(ESSAC) for selecting correct pairs of corresponding points, and estimating internal parameters of cameras in two or more smart devices set with different views. As a result, it is possible to estimate internal parameters of cameras embedded in two or more smart devices set with different views. Next, I propose a method for estimating human postures from the measurement result of multi-view human motions. Experimental results show that the proposed method can reduce computational cost, while achieving similar or higher accuracy of estimating human postures in ill-posed conditions.

In chapter 5, I develop an exertainment system based on human posture estimation in order that two or more people enjoy physical exercise together in a local community. I implement several physical exercises developed for elderly people on smart devices. Next, I develop an exertainment system using postures including in the above physical exercises that two or more people play together. Furthermore, I develop an exertainment system using robot balls which is simulated as Boccia. Preliminary experimental results show that the proposed system can evaluate the rhythm-motion synchronization by two people. Finally, I show the effectiveness of the proposed method by the multi-view evolutionary robot vision through various types of experiments on exertainment.

Chapter 6 concludes the thesis, and discusses future works towards the social implementation.