exercise demonstration performed by an expert. The system then detected mistakes and guided users on improving their performance. Three weight training exercises were studied, however system recognition performance to detect training errors were not analysed. The deployment of the Kinect camera constrained the field of view to a 2m distance from the system. Limbs should not be pointed directly at the camera or be occluded by the body, which limits the exercises that could be monitored. The related works discussed above focused mainly on gym monitoring applications for healthy subjects. Often these approaches relied on multi-sensor information and pattern recognition methods, requiring individual learning of motion pattern models. Our work aims at describing different training exercises with the same exercise quality parameters and a sinusoidal model. In our approach, a smartphone serves as single measurement, estimation, and feedback device for assessing patient exercise performances. We evaluate our method's recognition performance for classifying execution errors, which is necessary to deploy the system in practice and especially in a clinical application. To the best of our knowledge, no existing commercial or academic work exploits smartphones to assess training quality in chronic patients. Likewise, recognition performance for classifying execution errors was not evaluated in similar systems for a clinical application.

3.3 Smartphone-based training approach

The ability to perform particular motion exercises differs between trainees, due to individual motion constraints. Chronic patients often suffer from limiting pathologies and muscle weakness, thus may not be able to perform exercises at the same speed or range of motion of another trainee. To use the smartphone as an exercise monitoring and feedback device in this user group, it was attached in a holster to a body part or limb involved in the exercise. The phone's integrated inertial sensors could thus capture the motion performance. After performing one exercise, the holster could be moved to a position designated for the next exercise. Illustrations on the phone's screen guided the trainee during attachments. Here, we describe our training approach that includes Teach-mode and Train-mode operation as illustrated in Figure 6 and our motion exercise modelling approach.