The goal of this project is to develop a collaborative network, named RubiNet, dedicated to early childhood education. The network will aim to integrate the nationwide activities of children, parents, teachers, researchers, and classroom robots. As a one-year landmark project, we propose to develop and evaluate the seeds of this network at a model Early Childhood Education Center (ECEC) at the University of California San Diego.

The proposed activities will build upon our experience on the RUBI project (http://mplab.ucsd.edu) whose goal is to develop social robots for learning and education. Scientific documents from this project have been published at major scientific journals, including the Proceedings of the National Academy of Sciences (in press), have received best paper awards at scientific conferences like the IEEE International Conference on Robot and Human Interactive Communication, and have led to commercial software, e.g., smile detection, ported to a new generation of commercial digital cameras. The project has also generated public interest and has been featured in media outlets such as Good Morning America, the Financial Times, and Wired Magazine.

Figure 1: Each year of the RUBI project we developed a different robot prototype that incorporated the lessons learned from the previous years. Left: RUBI-1 was partially controlled by a human operator. Center: RUBI-2 goes for a nature walk with the children. Right: RUBI-3 Playing educational games. It operates fully autonomously for weeks at a time.
1 Proposed Activities

While the RUBI project will continue to focus on development and improvement of individual robots, here we request funds to create the seeds for RubiNet.

1.1 Robot construction

We propose to construct, deploy and maintain 10 robots (one per classroom) based on the RUBI-3 prototype we developed last year (see Figure 1). These robots will run state of the art perceptual software for social interaction developed at our laboratory, including facial expression recognition, auditory recognition of emotion, and interest estimation (see Figure 2). The underlying software architecture of these robots, named RUBIOS, has been designed with collaborative networking in mind. Each robot has its own IP, and the different robot components communicate with each other, and with humans, using an scalable Internet Chat-room architecture.

Figure 2: Left: Example smiles automatically extracted by RUBI-3. Right. Some of the complete images as viewed by RUBI-3.

1.2 Authoring Tools

We have developed games that teach educational materials (See Figure 3). On some of these games the robot presents items on its touch screen (e.g., pictures of geometric shapes), and says the name of a target shape (e.g., “Triangle”). If the children touch the wrong item, the robot shakes its head and encourages the children to try again. When the children are correct, RUBI dances, claps, and makes cheering sounds. RUBI’s teaching engine monitors the children interest and performance and decides when to change activities so as to optimize long-term learning. In other games the
robot displays an object on its touch screen and asks the children to find the object in the classroom (See Figure 1-Right). The robot takes the object, puts it in a box or gives it back to the children.

Here we propose to develop authoring tools for teachers to easily create and share their own educational games. To this effect each robot will host a classroom Web site with links to the proposed authoring tools. Teachers will download digital media, e.g., images and sounds of objects that they want the children to learn about. The robot will automatically create a new game and make it part of its own behavioral repertoire. We will also develop tools for teachers to customize the classroom robot. For example the teachers will download images and names of the different children in the classroom. Using this data the robot will train itself to recognize the children it interacts with.

The classroom robot will also be in charge of automatically generating a daily classroom blog accessible by parents and teachers. The blog, shall include digital media and text representing the daily life of the classroom. For example the blog may include automatically selected videos with the best smiles of the day and text describing the classroom mood and the games the children liked the most.

Figure 3: Left: RUBI teaching materials targeted by the California Results Developmental Profile from the California Department of Education. Right: Screen capture of a favorite game. Pointing to the face of a classmate. RUBI says the name of a classmate and the children point to it on RUBI’s touch-screen.

1.3 Collaborative Tools

The classroom Web site will link to a central repository of educational games and robot programs categorized by age and target skills. Classroom robots will automatically update statistics of the games in the repository, such as the age of the children that play the games the most, the amount of time children play the games, and the performance improvements as a function of time. In addition the repository will include ratings and comments from parents, teachers and scientists.
Collaborative filtering tools will be developed to suggest teachers new games based on their past preferences.

2 A Modern Tool for Behavioral Research

Besides its potential to transform educational practice, RubiNet is being conceived as tool to accelerate research on early education. A network like RubiNet could allow collection of scientific data on early education at massive scales, for very low cost, and at an unprecedented level of detail. These data could be used, for example, to understand the mechanisms by which socioeconomic factors impact early learning, or to develop standards for early detection of developmental disorders. To demonstrate this idea we propose to conduct a kick-off study that will use RubiNet to collect developmental standards for knowledge and expertise on facial expressions. These standards will become the basis for assessment of similar skills on children with facial expression processing impairments such as Autism Spectrum Disorders and Attention Deficit Disorders.