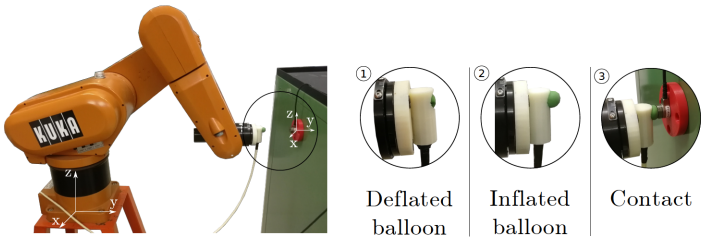

Figure 2.3: Experimental setup. *Phase 1*: the housing, mounted on the end-effector of a Kuka KR3 robot, hosts the pneumatic balloon deflated. *Phase 2*: the pneumatic balloon is inflated according to the desired pressure value. *Phase 3*: the pneumatic balloon comes into contact with the ATI sensor attached to a wall.

2.2 Experimental evaluation

In order to characterize the usability of the proposed sensing system, we conducted four experiments. The first one evaluated the relation between the variation of the internal pneumatic pressure and the applied force; the second and the third experiments validated the proposed system comparing the estimation of the force performed by the pneumatic balloon with the one measured by a commercial force sensor, considered as ground truth, in two different tasks. The fourth experiment aimed at testing the pneumatic sensor during contact actions with either non-planar or inclined surfaces.

Experimental setup All the experiments shared the same experimental setup. The pneumatic balloon housing was attached to the end-effector of an industrial robot KR3 (KUKA Robotics, DE). In front of the robotic manipulator, within its workspace, there was a flat wall the balloon was supposed to come into contact with. Interaction forces were measured by a ATI Nano17 six-axis force/torque sensor (ATI Industrial Automation, USA) placed on the wall at the contact site (see Fig. 2.3). Its main features are the small size (17 mm diameter) and a very high resolution (0.00312 N), with a measurement range of ± 17 N for the normal direction and ± 12 N for the others.

The motion of the robotic arm was constrained along its y-axis, i.e., the normal direction with respect to the the balloon exit wound and the force sensor, thus the wall. This particular experimental setup permits to carry out the same experiments an arbitrary number of time in the same condition, i.e., a high degree of repeatability is granted. Data were analyzed on MATLAB 2015b (MathWorks Inc., USA).