A short history of omnidirectional wheels

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Omnidirectional wheels have been used in robotics, in industry, and in logistics for many years. The main source of omnidirectional wheels are companies which produce them for omnidirectional conveyor systems, for example, for handling packages. Omnidirectional wheels are popular for omnidirectional robots, specially in the RoboCup setting. An omnidirectional robot can drive along a straight line from point A to point B, while rotating along the line in order to arrive with the correct orientation. Omnidrectional wheels have also been used for wheelchairs, for service vehicles in airports, and many other applications.

It is not widely known that the very first omnidirectional wheel was patented in 1919 by J. Grabowiecki in the US [1]. Fig. 1 shows an image from the patent application. The assembly consists of a main wheel and transversal rollers, such as those used by most RoboCup teams. As early as 1907, inventors were considering the design of vehicles capable of moving forward and sideways without steering the wheels [2].

One of the first modern omnidirectional wheels was developed by the Swedish inventor Bengt Ilon around 1973 [3]. Fig. 2 shows the design of the Ilon wheel and a fork lift built using them. The profile of the wheel is very nearly circular. The wheel is omnidirectional but transversal forces produce excessive friction in the axes of the small rollers. A clever alternative are “Killough rollers” [4], which are usually built using two truncated spheres. Such rollers were used by the Cornell RoboCup team in 2000, and were still in use until 2004 in RoboCup competitions. Although the rollers are named after Killough, the rollers had been actually patented in 1980 by Bradbury [5].

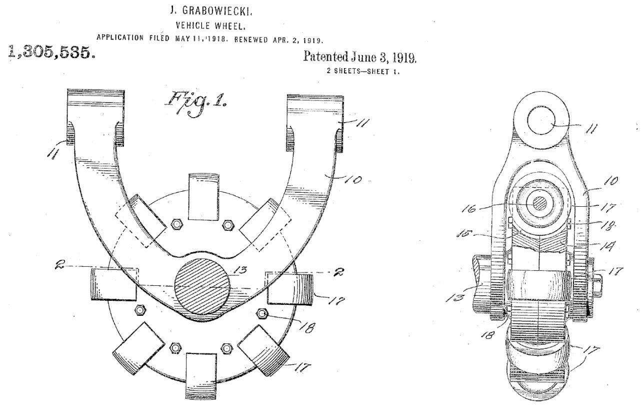

Fig. 1. Drawing of probably the first omnidirectional wheel, as described in Grabowiecki's US Patent of 1919

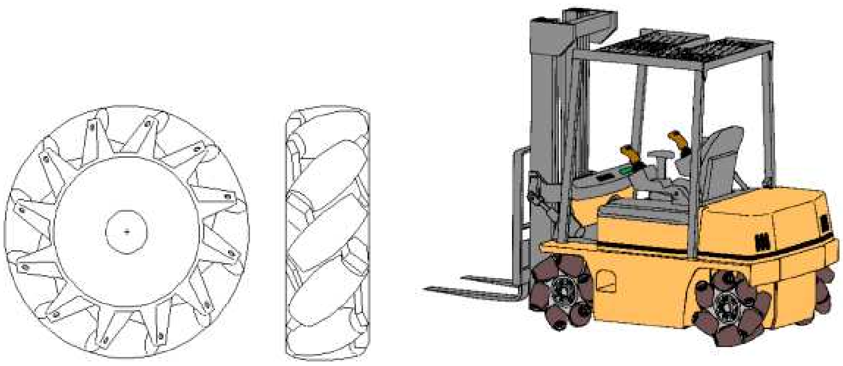

Fig. 2. Omnidirectional wheel and omnidirectional fork lift

Fig. 3 shows an example of the kind of vehicles that can be built with the Killough wheels (left), and with a double omnidirectional wheel, each with only two rollers, in order to provide a circular profile (Fig. 3, right).

Many RoboCup teams use now self-built wheels or a variation of commercial wheels for conveyor systems, such as those shown in Fig. 4. Geometrically, such wheels are polygons with small transversal rollers at the polygon's corners (as

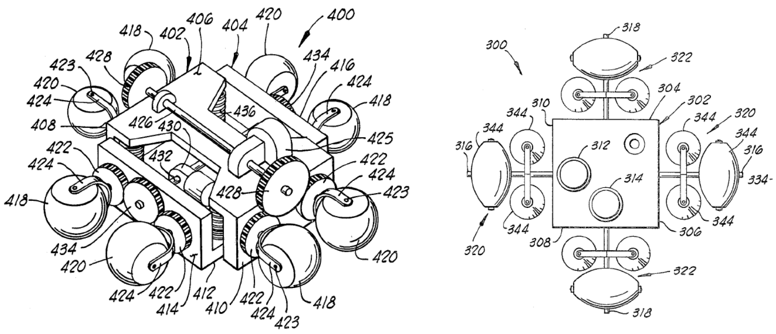

Fig. 3. Two vehicles with omnidirectional wheels, as in [5]

Fig. 4. Segmented omnidirectional wheel and a commercial double wheel

can be seen in the left wheel). Blumrich managed to patent similar wheels in 1974, although they are just a simple variation of the Grabowiecki wheels [6]. The wheels are made round by using a stack of two of them and avoiding any gap in the wheel profile (right wheel in Fig. 4). The point of contact changes from one wheel to the other as the complete wheel rolls. A theoretical analysis of omnidirectional wheels with transversal rollers and gaps can be found in [7].

Much effort has been spent on improving the Swedish or Mecanum wheels, as they are sometimes called [8]. The omniwheels can only roll smoothly if the profile of the complete wheel assembly is perfectly round, without gaps. Therefore, some groups have used spheres as a basis for the robot. The spheres can be activated with rollers, as in a mechanical mouse [9], or a group of spheres can be moved by chains or transversal bars [10],[11]. The spheres provide smooth rolling but the necessary mechanics is rather bulky. Conventional wheels can be also used for omnidirectional robots, if the wheels are rotated by a second steering motor [12].

It has been thought for many years, that the only way of providing a smooth rolling effect when using omnidirectional wheels with gaps between rollers is: a) by stacking two wheels on the same axis, producing a combined circular profile; b) by using several synchronized wheels which combine in order to support the vehicle keeping the distance to the floor constant (as in Fig. 3); or c) by using spheres or quasi-spheres as wheels (in the movie iRobot, for example, cars are omnidirectional and roll on spheres). There is a fourth alternative, which is to design omniwheels with a circular profile, in which the gaps are almost closed by using two kinds of rollers alternatively, as in [13]. Long and short rollers alternate on the periphery of the wheel.

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