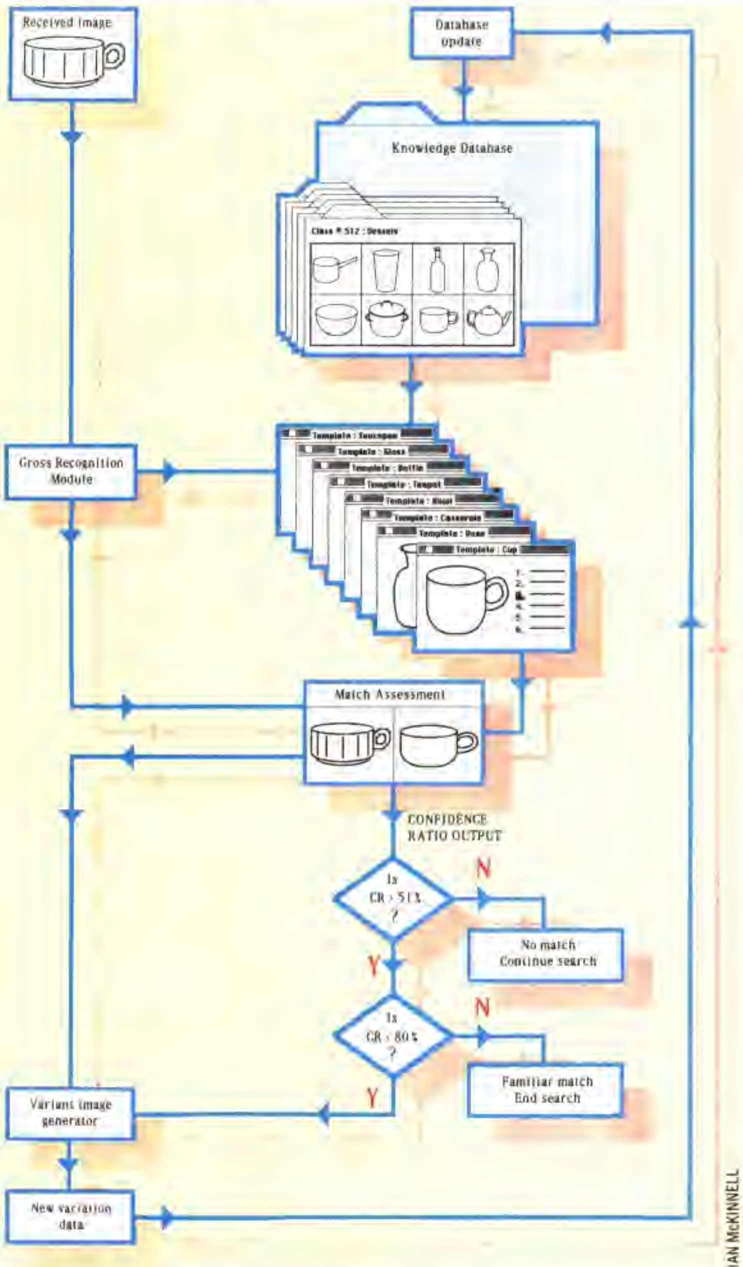
Visual Variations
Knowledge of an object can be stored as a 'template' image of the archetypal object, plus a series of variation data statements; each variation statement can be applied to the template to produce a different image that still fits the type definition. An image from the robot's sensors is scanned by some gross analysis module that gives a first guess at the class of object in view. Each object in that class is then matched in all its variations against the received image until a match is found. The statistical confidence with which this match is made determines whether the new image's variations from the template are radical enough to require a new variation data statement to be generated from it

expect, realistically and practically, of future robots? Let's take a look at each of the major design areas in turn.

MOVEMENT

It is extremely unlikely that robots will walk on anything resembling a human leg in the near future. Too much processing time and space would have to be devoted to the effort of maintaining balance, while robot joints and electric or hydraulic musculature lack the flexiblity or freedom humans are accorded by the interaction of muscle, tendon, and cartilage. In addition, there are many times when a robot would be severely hindered by having to get around on two legs. Recently, though, some experimental robots have been built with four or six legs, resembling insects. This may offer an interesting design variation for some robot applications.



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For other applications, such as military operations, planetary exploration, and more conventional uses around the home, wheels currently offer the most practical method of movement, and this is unlikely to change. Robot movement will become more fluid, but will probably never rival the beauty and grace of a human athlete in motion.

Many industrial robots and smaller robot arms are necessarily fixed in place, with their movements confined to a very specific area of action, since they are designed to perform one or two well-defined tasks. Unless the nature of industrial assembly changes radically, even roving industrial robots will probably remain relatively confined: they will continue to follow tracks, ride on rails, or swing from overhead racks. It is possible that advances in automation and robotic design will bring about a radical change in industrial production methods, but it is impossible to predict what such changes might be.

One key element of movement is the necessity of the robot to respond to its environment. This means that the robot must be well equipped with a sensory system, and that sensory input must correlate directly with its movement.

SENSORS

Robots can be fitted with sophisticated sensing equipment that extends their perceptions in areas new or unfamiliar to humans. Proximity sensors, motion detectors, precise discrete positional feedback devices and noise detectors with a very large range of perceptible frequencies all give a robot the ability to collect more varied data than a human can. Visual systems are becoming more accurate, with increased resolution of perceived images. Voice synthesis and recognition techniques, still in the very early stages of development, are certain to become increasingly sophisticated and will play a major part in the development of robotics.

Utility robots, used mainly in industrial applications, will most likely continue to be fitted only with those sensors required to perform their given tasks. Robot arm welders, for example, have no need for speech or complex visual feedback. They can perform their jobs accurately and quickly, with a minimum of sensory input, and extraneous perceptions would possibly be a hindrance.

General-purpose robots, designed to learn from experience and emulate human thought processes, would have to be fitted with as many sensors as possible. It would be crucial for the robot to be able to investigate its environment independently and assimilate the information it gathered. Humans rely heavily, for instance, on a combination of visual and auditory feedback to comprehend speech. We often tend to ignore this synthesis of sensations, particularly when thinking in terms of robot design. But for a robot to communicate with a human being, to understand language rather than merely recognise it, such a