Robot Sensing and Perception

some of the research done in the *SMRLab*

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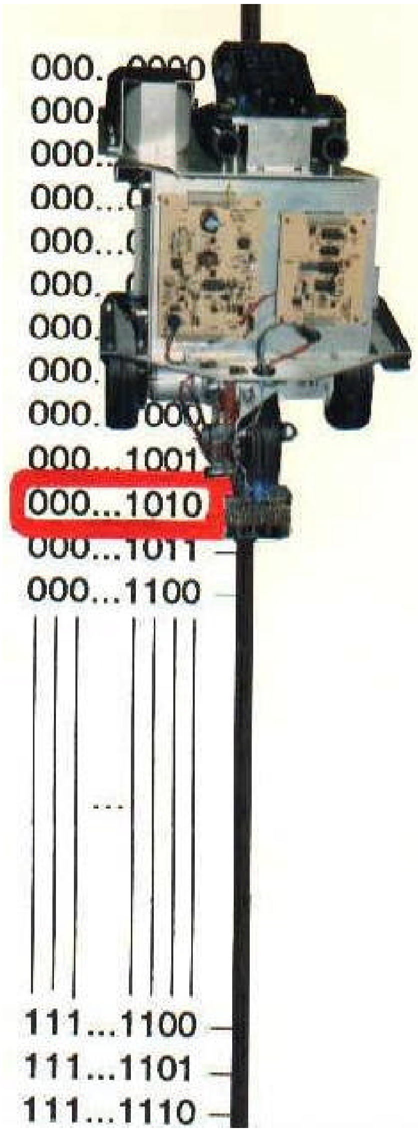
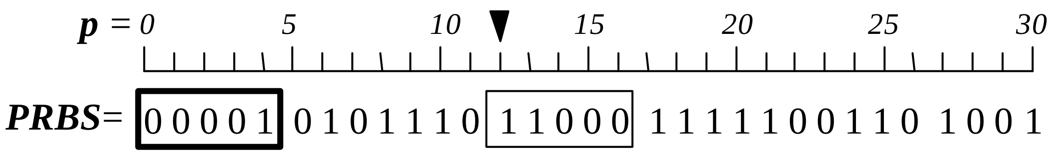


Why natural binary coding cannot be used in practice for absolute position recovery ?

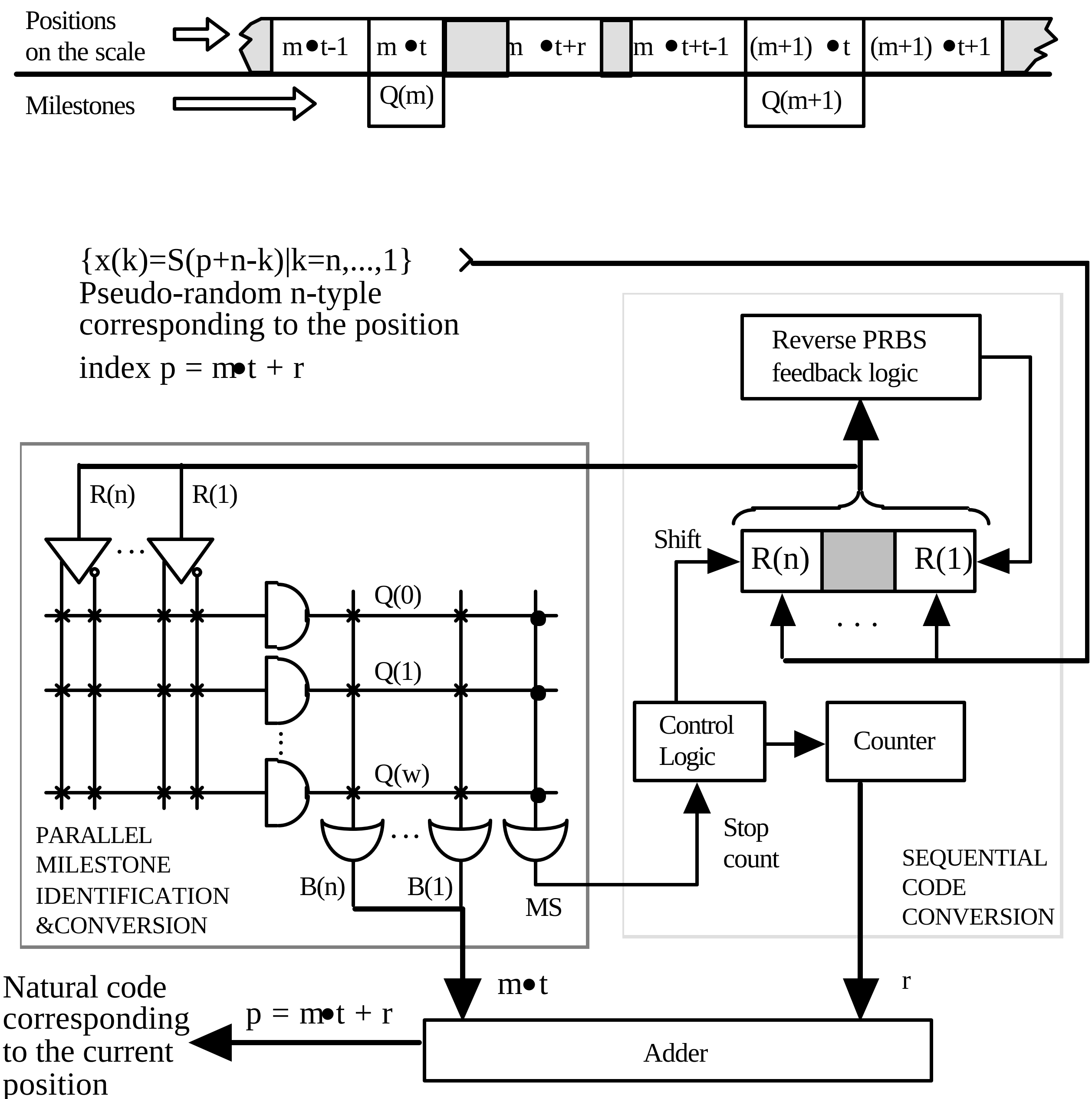
A n-bit code would be needed for each quantization step, resulting in *n* binary tracks in parallel with the guide-path. For instance, the encoding of a 160 m long guide-path with a 0.01 m resolution would need 14 tracks running in parallel with the guide path

➔ *pseudo-random encoding provides a practical solution allowing absolute position recovery with any desired n-bit resolution while employing only one binary track, regardless of the value of n.*

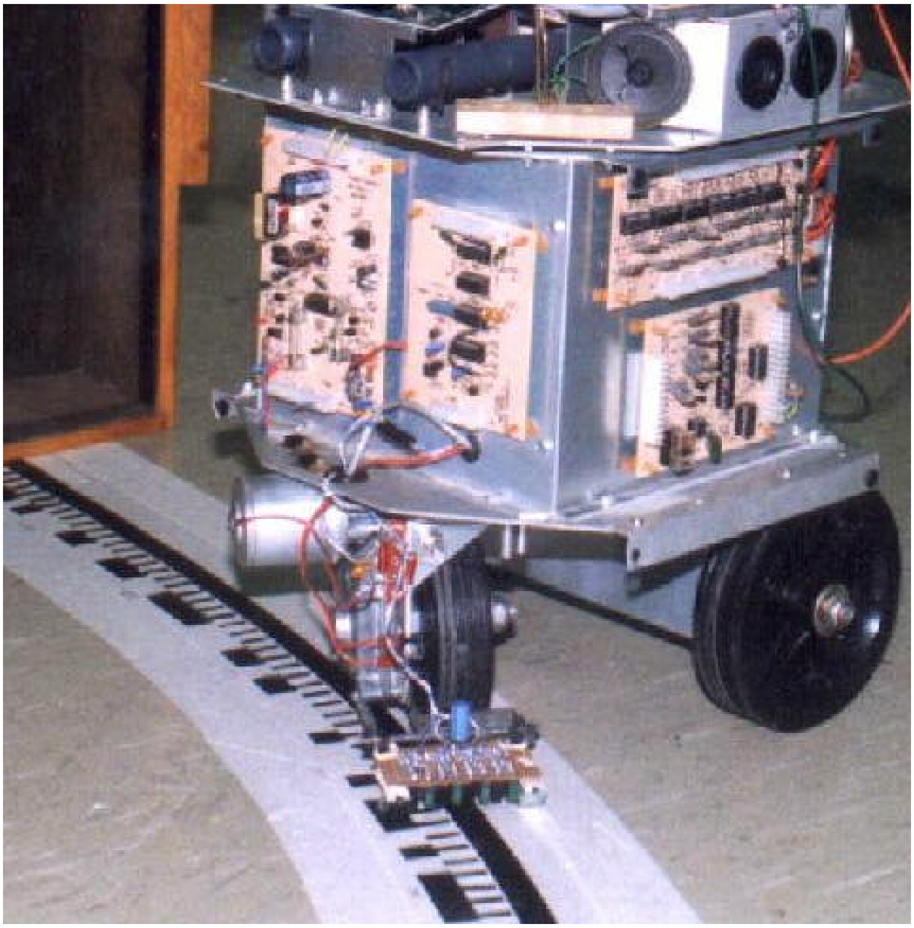


A (2^n -1) term Pseudo-Random Binary Sequences (PRBS) generated by a *n*-bit modulo-2 feedback shift register is used as an *one-bit / quantization-step* absolute code. The absolute position identification is based on the PRBS window property. According to this any *n*-tuple seen through a *n*-bit window sliding over PRBS is unique and henceforth it fully identifies each position of the window.

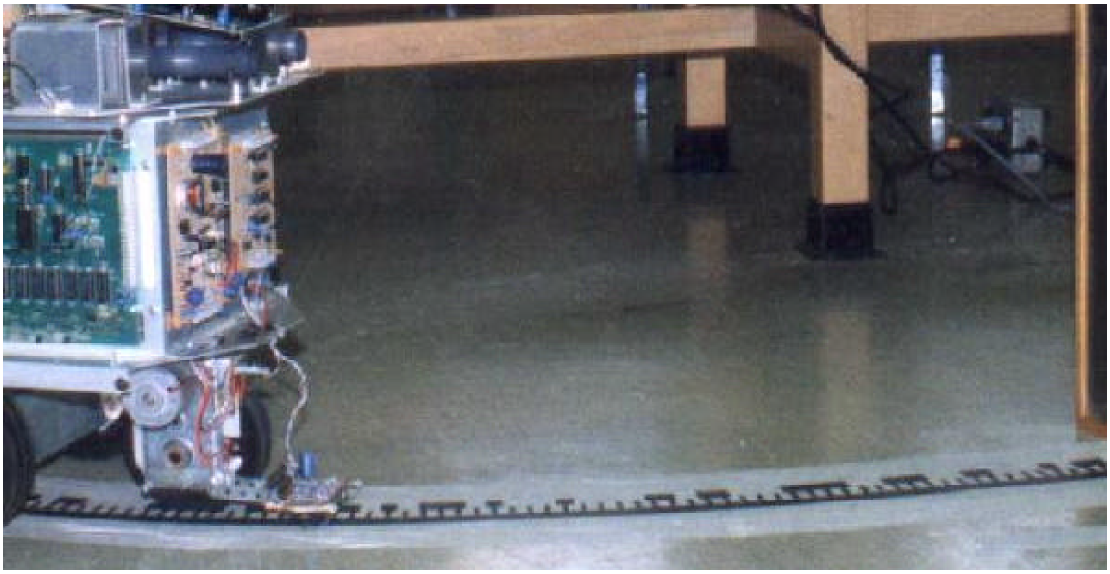
The figure shows, as an example, a 31-bit term PRBS: 0, 0, 0, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 1, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 1, 1, 0,1, 0, 0, 1, generated by a 5-bit shift register. The 5-bit n-tuples seen through a window sliding over this PRBs are unique and represent a 1-bit wide absolute position code.



Serial-parallel *pseudo-random / natural* code conversion algorithm

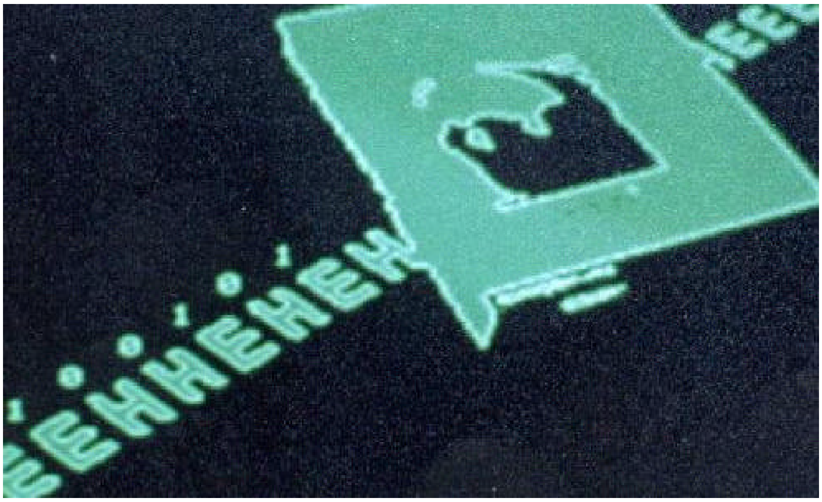


Pseudo-random encoded track (one bit per quantization step) allows recovery of the absolute position of an optically guided Automated Guided Vehicle (AGV)



Optically guided AGV tracking the pseudo-random encoded track

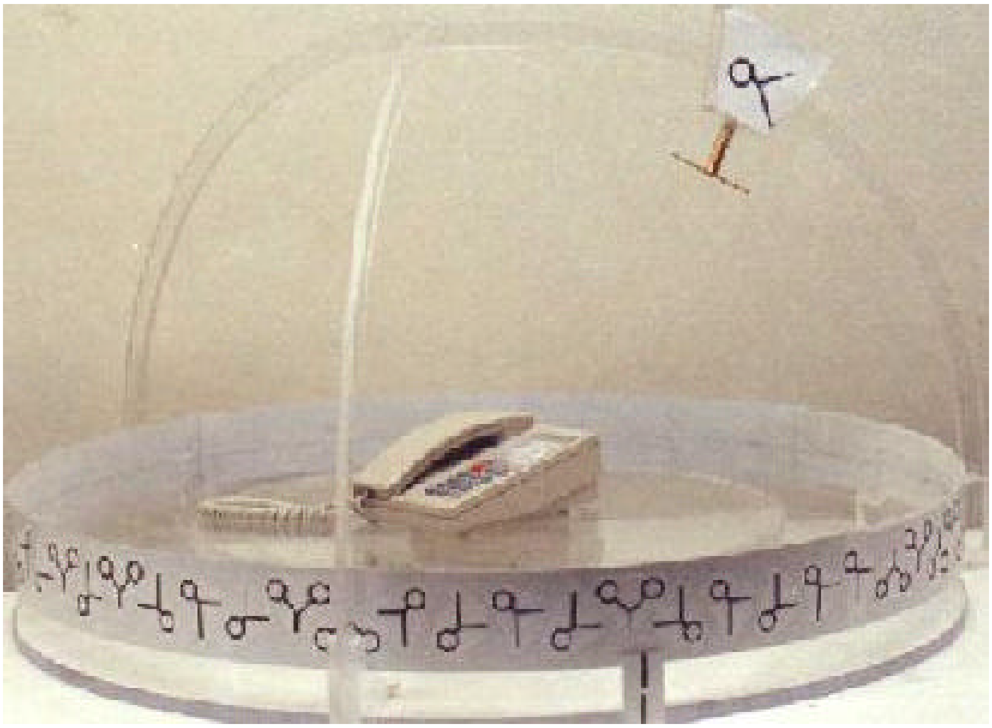
Pseudo-random encoded guide path allows recovery
of the absolute position of an AGV using computer vision



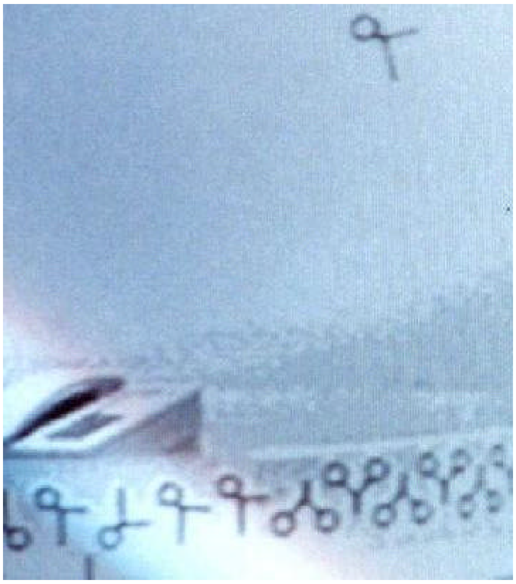
Computer vision recognition of the
pseudo-random binary code

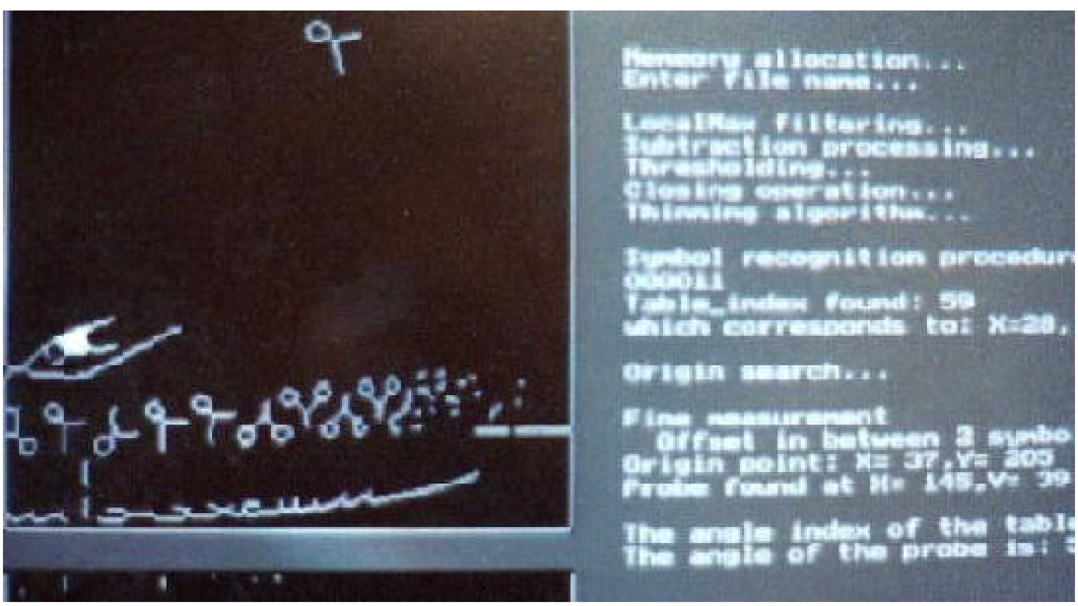
Model-based recognition of a pseudo-random encoded object

Wall-mounted pseudo-random encoded guide path allows recovery of the absolute position of the AGV using computer vision

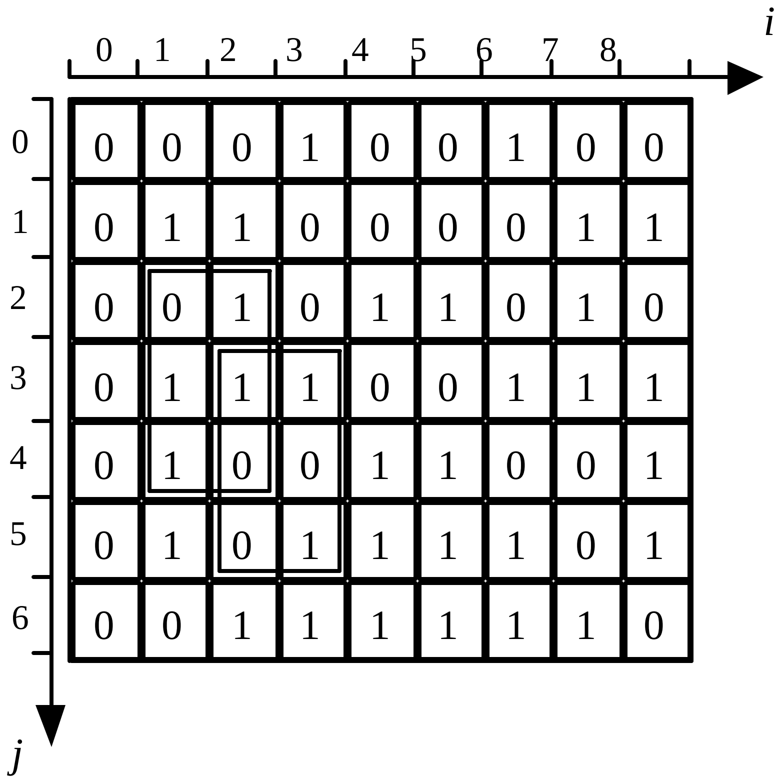


Pseudo-random encoding for computer vision recovery of the 3D position of a probe mapping the electromagnetic–field radiated by a telephone set

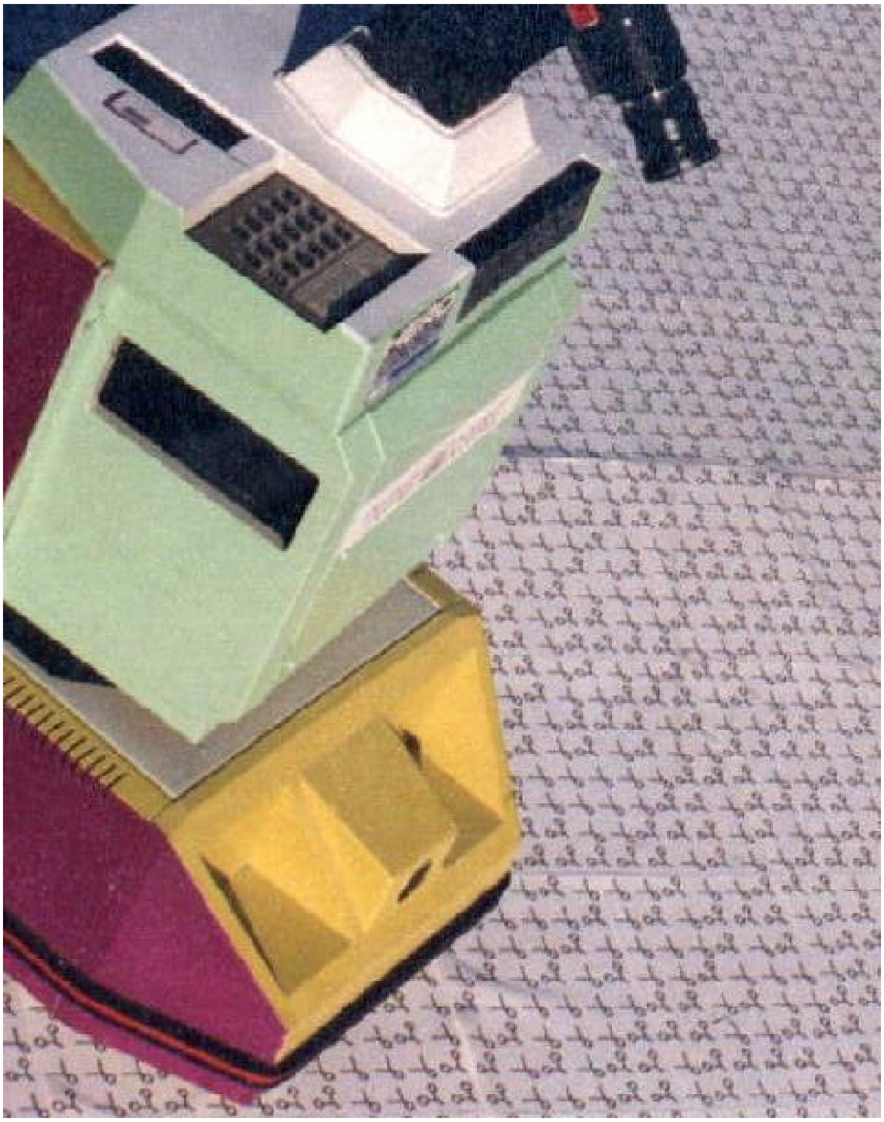




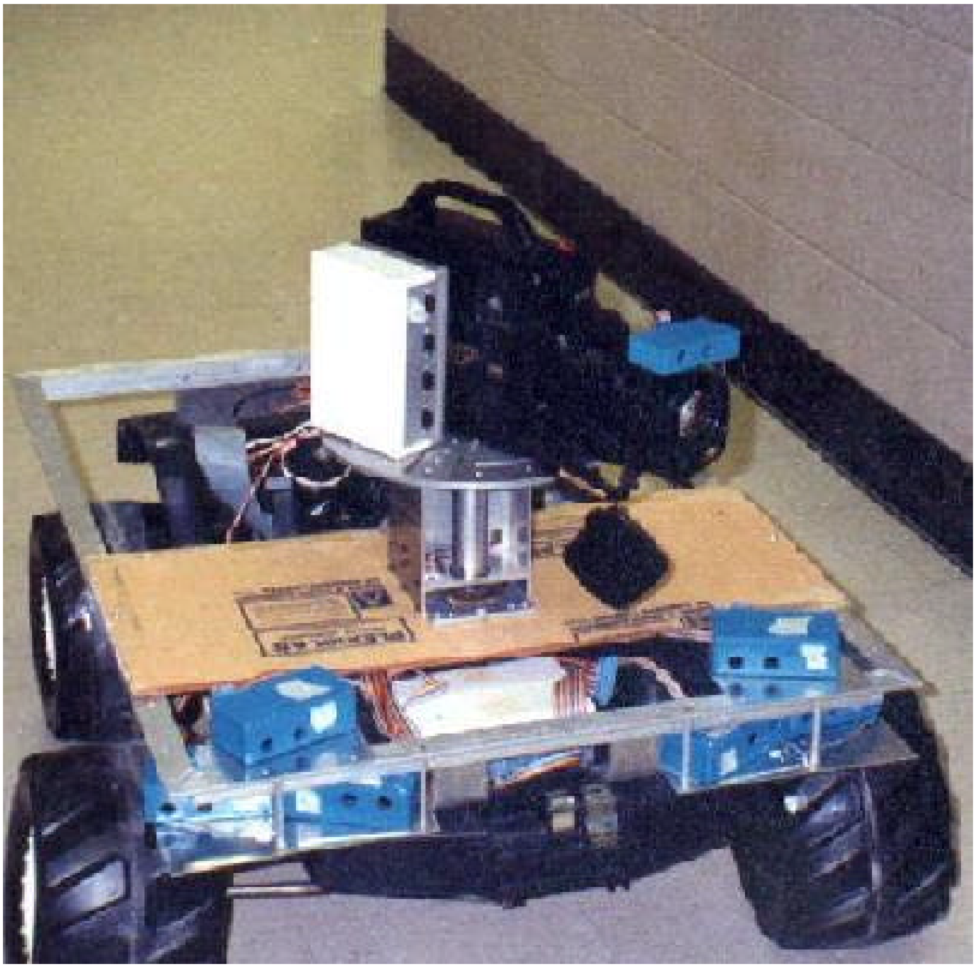
Computer vision recovery of the pseudo-random code



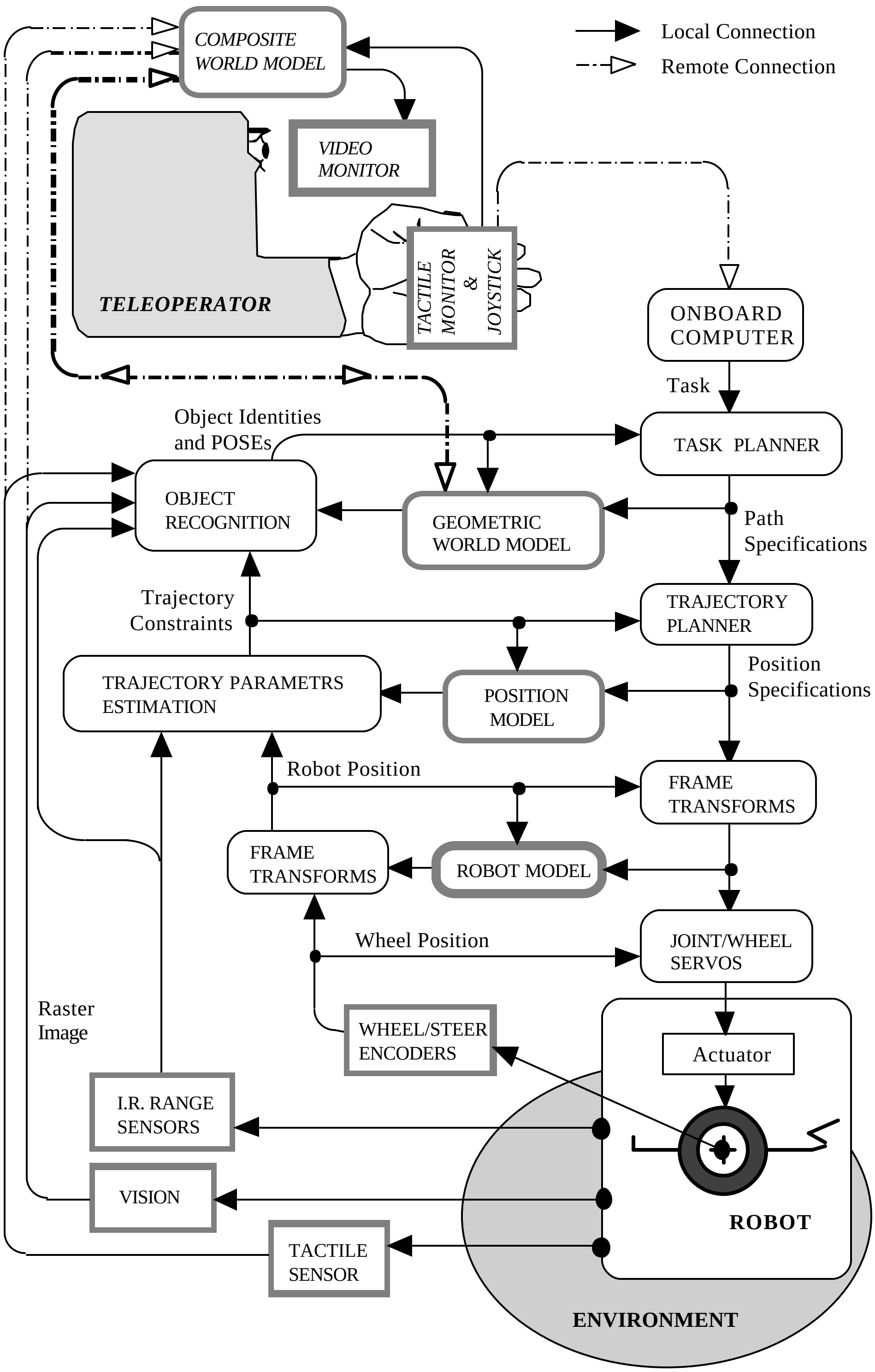
Illustrating the window property in a Pseudo-Random Binary Array (PRBA). The 3-by-2 code seen trough a window on a 7-by-9 PRBA is unique and used as absolute code for the window position (*i,j*).



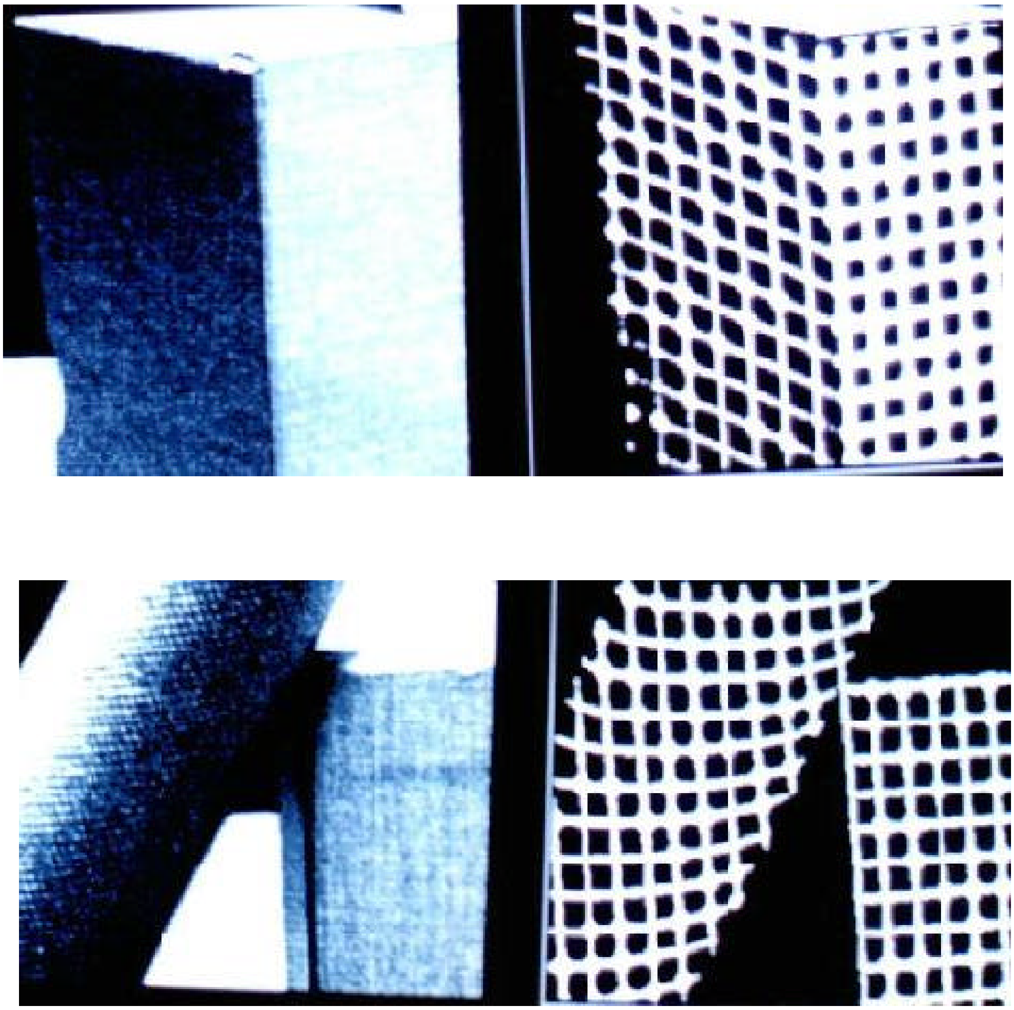
Pseudo-Random Binary Array (PRBA) encoding for the recovery of the 2D absolute position of a free ranging mobile robot using computer vision



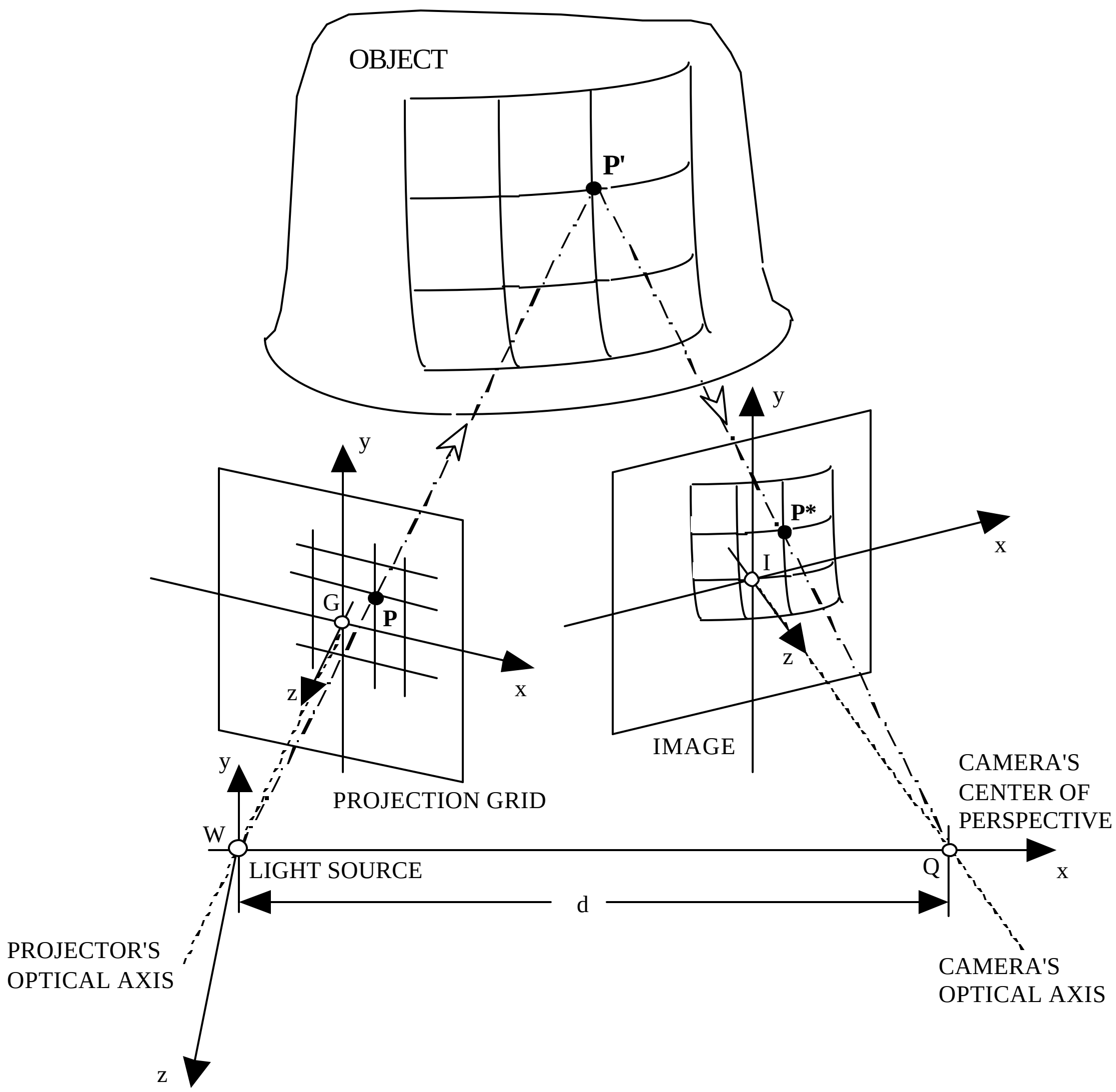
Mobile robot navigation using multiple IR sensors and vision



Model-based telepresence control of the mobile robot

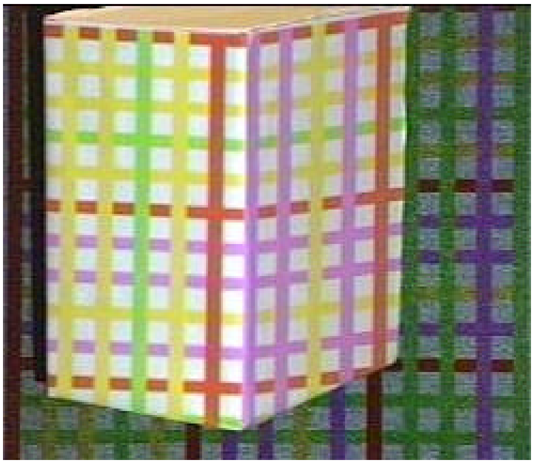


Recovery of the 3D shape of objects using structured light

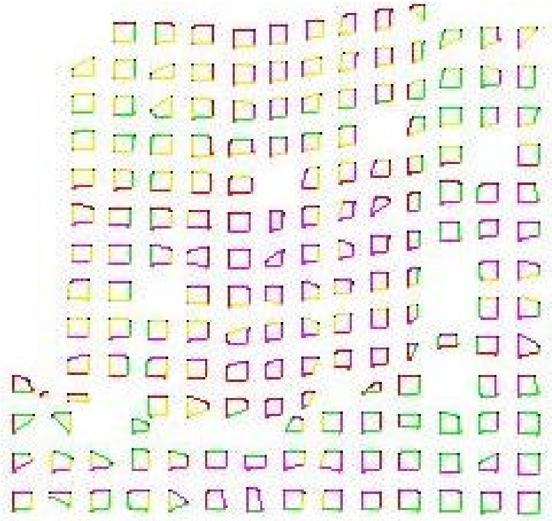


Point identification problem in pseudo-random encoded structured light

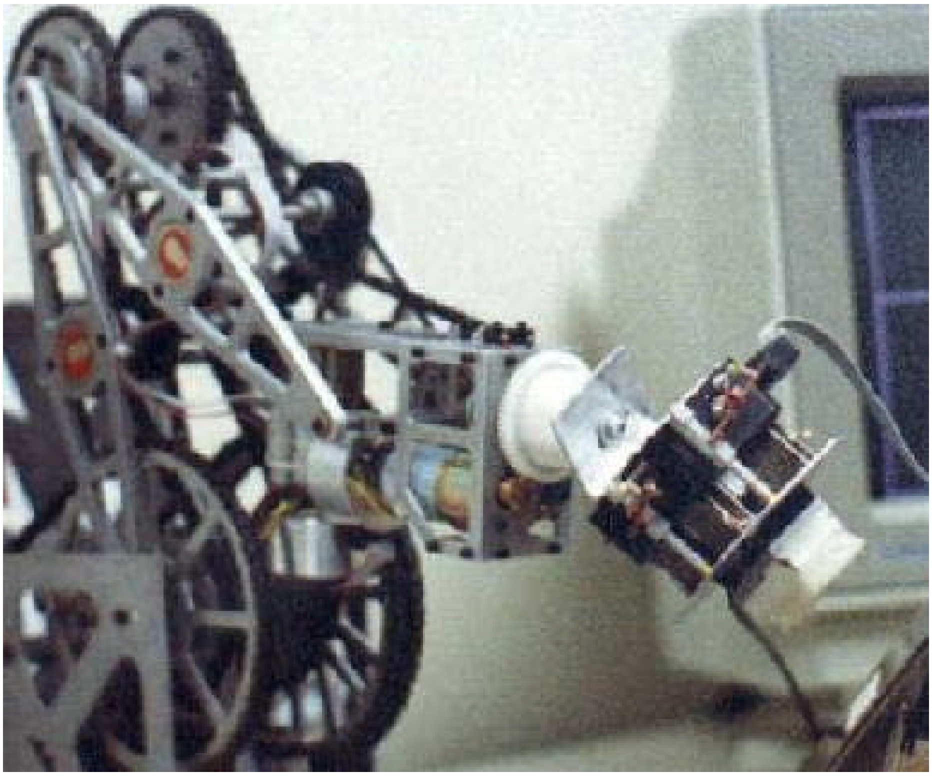
Pseudo-random color encoded structured-light grid projected on a 3D object



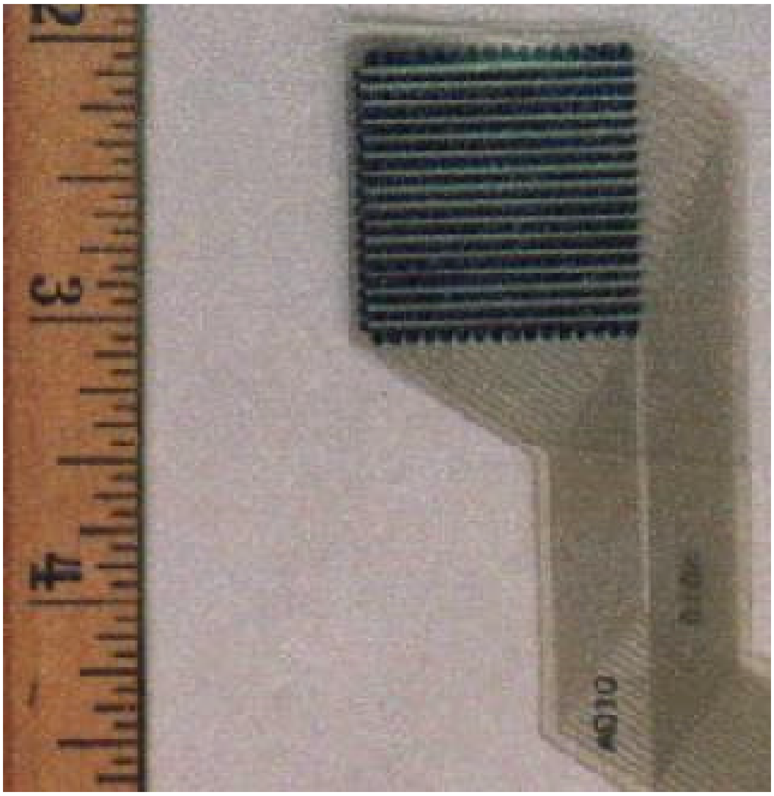
Pseudo-random color encoded
structured light grid projected on a cube



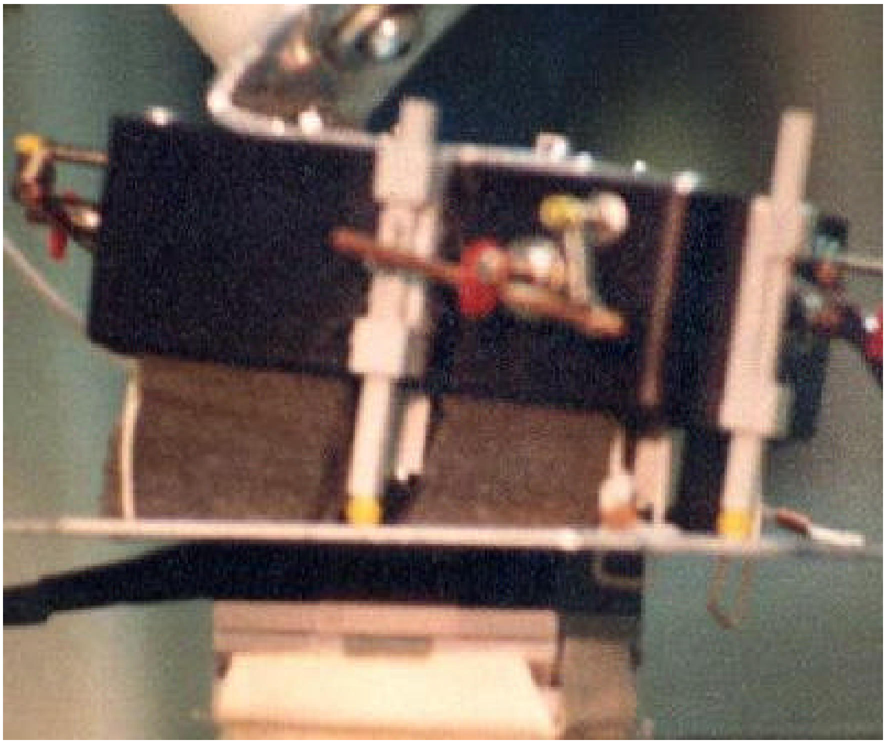
Recovered corner points at the intersection
of grid line edges



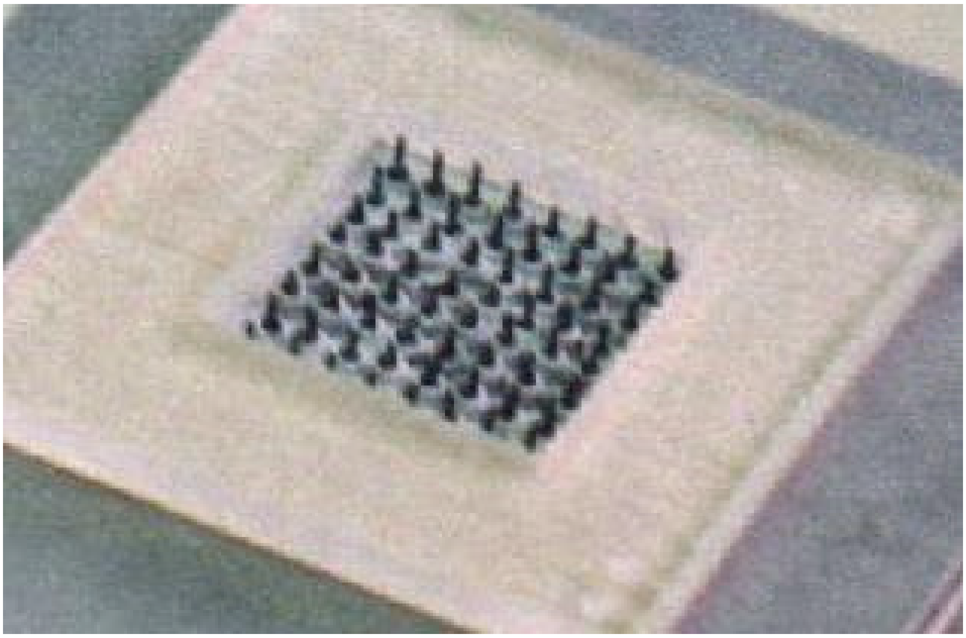
Haptic perception of 3D object geometry: the robot arm provides the *kinesthetic* capability and the tactile sensor probe provides *the cutaneous* information



Force Sensitive Resistor (FSR) tactile sensor array,
16-by-16 sensing elements on a 1 square inch area



Instrumented passive compliant wrist for tactile exploration of objects



“Tactile display” for computer-human interaction allowing humans to feel through their own touch sense computer-generated geometric profiles. It consists of an array of 8-by-8 vibrators on a 1 square inch area.