MegaPixel Ltd.

The Scientific and research-based company MegaPixel Ltd. was founded in 1989 in Moscow, Russia. The company is engaged in development software and hardware for computer vision system based on neuro-like algorithms.

MegaPixel Ltd. has already implemented more than 20 scientific projects in cooperation with USA, Italy, German parthners. Our main applications are:

- Vehicle license plate recognition systems,
- Video surveillance motion detector systems,
- Systems for reading symbolic information from trains and containers,
- Computer vision systems for robots,
- Intelligent video scanners for OCR in non-standard applications such as reading factory numbers from car engine,
- Automatic reading machines (for reading books, newspapers, indicators, indexes, and ect.) for the visually impaired.

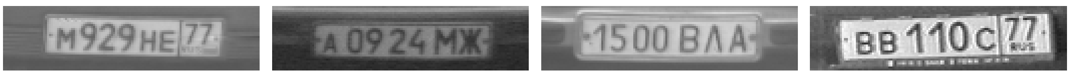
MegaPixel is unique in that it provides solutions based neuro-like algorithms that function in a manner similar to human optic system.

License Plate Recognition System

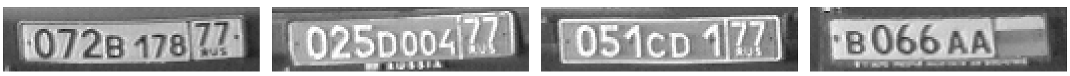
MegaPixel has been developing license plate recognition systems since 1995. The systems were first developed for recognition of Russian plates which are often more difficult to read that those in other countries.

Russian License Plates

Russian license plates exist in 16 combinations of digits and letters, which can be both large and small, black and white:



Most frequently occurring license plate types



New license plate types

Old license plate types

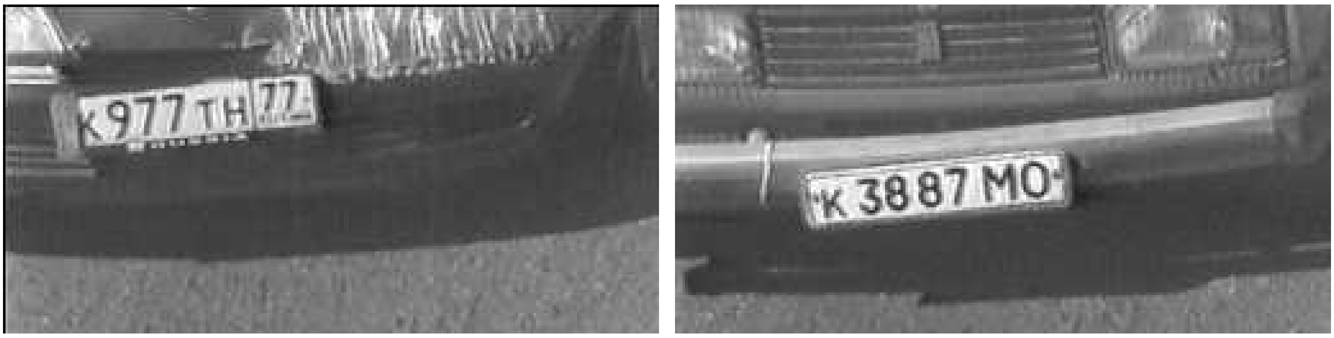
Transit license plate types

Plates for countries near to Russia present even a greater variety.

Russian license plates not always are pure. It is a dirty, salt, dust:

Other difficult images (shadow problems):

Some car after failures (distorted license plates):



Other distorted license plates:

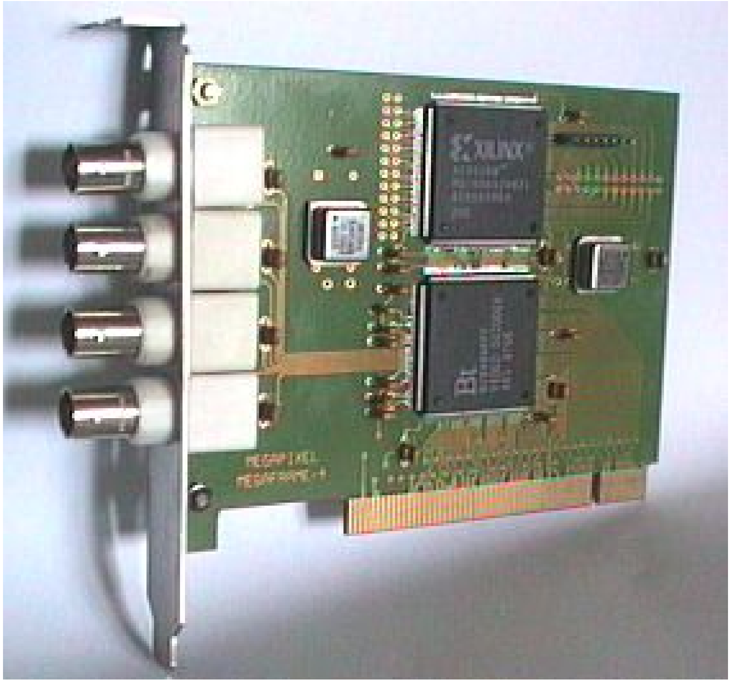
Problems of the imperfect equipment and communications:

These problems present real challenges to plate recognition systems.

MegaPixel's Systems

The first MegaPixel's system MegaCar was developed in 1996. The basis of the system was an ISA-bus Image Processor MegaFrame-3 from Megapixel. The frame size was 336*192*8 bit grayscale. The working range of the vertical size for standard size characters was 12-16 pixels (on the average 14 pixels). As the vertical size of the standard size characters is 80 mm (all European plates are the same), the field of view is 1.9 m:

The second MegaPixel's system CarFlow was developed in 1998. It was the PCI-bus Image Processor MegaFrame-4.



MegaFrame-4

The frame size for MegaFrame-4 is 768*288 gray or color pixels (rectangular, not square, pixels). MegaFrame-4 works much faster then MegaFrame-3.

The first: PCI-bus much faster then ISA-bus.

The second: MegaFrame-4 has the powerful hardware support of the Xilinx FPGA chip. This chip is suitable because the MegaPixel's neuro-like algorithms (Gaussian functions) use only 8 fixed bits while completely corresponding to the dynamic range of a real neuron - 1:10. Hence, there is no need for an expensive DSP solutions with floating point. Maximizing the resolution on the horizontal axis has allowed us to reduce the vertical size up to 10 pixels. It corresponds to a field of view approximately 3m:

Width of a Field of View, Character's Resolution

Today approximately 30 companies offer License Plate Recognition Systems including Automatic Number Plate Recognition, Electro-Optical Technologies, Inc. and PhotoCop.

Unfortunately, the majority of the companies do not specify characteristics of the systems. Therefore, for comparative analysis, which is not complete, the systems of Talon from Racal Messenger Ltd., IMPC from Optasia Systems Pte Ltd. and materials from an excellent article "Opening the Shutters on Traffic Surveillance" from PULNiX America, Inc. were chosen.

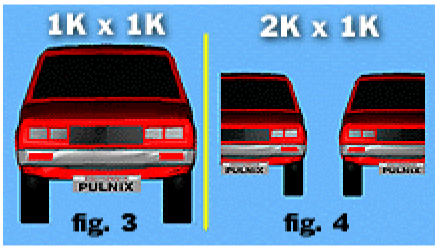
One of the requirements stated by Talon is "Size of a plate: Between 25% and 33% of horizontal field of view of camera". This corresponds to a field of view from 1.5m to 2.0m (length of all European plate is 0.5m) or a resolution from 15 to 20 pixels per character.

One of the requirements stated by IMPS is "The character's height as captured would be at least 18 pixels high". This corresponds to a field of view 1.7m. All calculations are made for European license plates.

The author of the Article writes, "For typical OCR reading, it is necessary to have at least 10 pixels/inch." This corresponds to a field of view 1.95m or a resolution 22.5 pixels per character (USA license plate, square pixel progressive scan camera is used).

PULNiX America, Inc. is the World Leader in progressive scan technology. This company was the first to understand the necessity of creating special cameras for ITS (Intelligent Transportation System) applications. Progressive scan technology is necessary primarily to increase a field of view.

PULNiX has developed two types of traffic cameras for ITS applications. One is the TM-9701TC, which is 768 x 480 pixels with a 4:3 aspect ratio and the TM-1001TC having 1K x 1K pixels with a 1:1 aspect ratio. PULNiX also creates the new 2K x 1K camera with 16 : 9 aspect ratio.



Field of view and camera aspect ratio.

This picture is taken from article, of mentioned above. Note: in the article USA license plates are used which are of a different size.

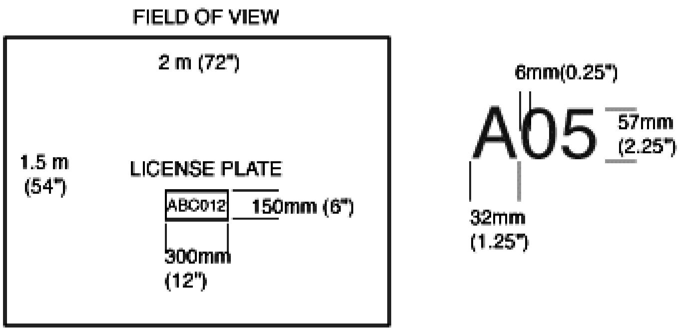


fig. 5 Typical field of view for OCR.

This picture is taken from same article.

The summary Table 1 contains results of calculations for various systems and cameras. Note: Russian license plates contain small character, which are 75% of standard. Therefore the table contains separate results for Russian license plates.

Table 1. Width of a field of view (in meters)

Systems	Standard Camera 768x288	Progressive Scan Camera 768x576	Progressive Scan Camera 1Kx1K	Progressive Scan Camera 2Kx1K
Talon (Europe)	2.00m * 15 pixels	4.00m ** 15 pixels	5.21m ** 15 pixels	10.42m ** 15 pixels
Talon (USA)	1.44m * 15 pixels	2.88m ** 15 pixels	3.75m ** 15 pixels	7.50m ** 15 pixels
IMPS (Europe)	1.69m * 18 pixels	3.38m ** 18 pixels	4.40m ** 18 pixels	8.80m ** 18 pixels
IMPS (USA)	1.26m * 18 pixels	2.52m ** 18 pixels	3.28m ** 18 pixels	6.56m ** 18 pixels
Article (Europe)	–	2.70m 22.5 pixels	3.51m 22.5 pixels	7.02m 22.5 pixels
Article (USA)	–	1.95m 22.5 pixels	2.53m 22.5 pixels	5.06m 22.5 pixels
CarFlow (Europe)	3.79m 8 pixels	5.78m 10.5 pixels	7.52m 10.5 pixels	15.04m 10.5 pixels
CarFlow (USA)	2.77m 8 pixels	4.17m 10.5 pixels	5.43m 10.5 pixels	10.83m 10.5 pixels
CarFlow (Russia)	3.03m 10 pixels	4.33m 14 pixels	5.64m 14 pixels	11.28m 14 pixels

* - There are no data whether the double resolution on a horizontal is used.

** - These result are calculated from the assumption that at work with the standard camera (768x288) the double resolution on a horizontal is not used (384x288 is used only). Otherwise a field of view will be less.

MegaPixel continually searches for other ways to increase a field of view. Today MegaPixel is testing the CarFlow II. In this system two synchronous standard cameras and one Image Processor MegaFrame-4 are used. The fields of view of the two cameras are overlapped. The resulting field of view of the system reaches 5.5m (for Russian license plates). The variants of parallel work two and more MegaFrame-4 for acceleration of work of system and increase of a field of view (at connection more then two cameras) are investigated.

Car Flow II

Speed of Processing

One of the most important characteristics of a license-plate recognition system is the speed of processing. In MegaPixel's systems the original neuro-like algorithm of license plate detection is used. The algorithm works both for front and for rear license plates. The special external trigger is not necessary. This is very important for systems with a wide field of view, as there is often multiple vehicles in one image.

The MegaPixel's algorithm is multizoned - up to 16 zones of license plates can be detected simultaneously. The speed of processing does not depend on number of the detected zones.

The processing time for CarFlow is 40ms,

The processing time for CarFlow II is 60ms.

After detection of a zone, the image of a license plate (192x24x8bit) is preprocessed. Removal of false detection, cleaning, definition of type - black or white, expansion and binarisation functions are performed.

The processing time for removal of false detection is 0.5ms.

The complete preprocessing time for one zone is 3.0ms.

The final process is Optical Character Recognition (OCR). The processing time is approximately 20ms. All processing times are given for Pentium II/ 400 MHz processor. For comparison in system IMPS: "Response Time - time taken to read the plate number. This ranges from 0.4 to 2 seconds, configurable".

Contrast of a License Plate

Another important parameter of an LPR-system is minimal contrast of the image of a license plate. Talon defines “Contrast” as, “The difference between average character intensity and average plate intensity must be greater than 25% of difference between peak black and peak white luminance signals".

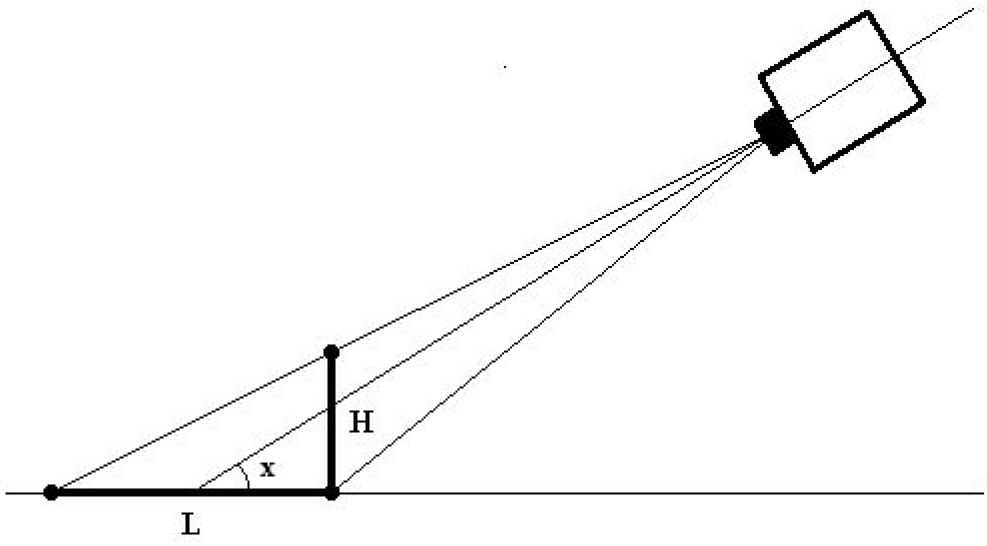
Using this definition of contrast, MegaPixel's systems can work with 5%-contrast images of license plates.

5%-contrast license plate

Maximal Speed of a Vehicle

What is the maximal speed of a vehicle can be? This value depends from many conditions.

The figure illustrates typical installation of a camera for LPR-system.



X - look down angel;
L - field of view on a horizontal (car flow direction);
H - field of view on a vertical.

The LPR-system should, at minimum, capture one image of the license plate of passing vehicle. Therefore maximal speed **S** should be limited so that in detection cycle time **T** the vehicle passed distance no more then **L**:

$$S = \frac{L}{T}$$

Then:

$$L = H \cdot ctgX \qquad H = \frac{C \cdot (V - P)}{P}$$

C - height of characters (meters);
P - resolution (pixels per character);
V - vertical resolution of a camera (for CCIR - 288 pixels, halfframe).

(V - P) means, that license plate should be inside a field of view completely.

The following is the resulting formula for calculation of maximum allowable vehicle speed:

$$S = \frac{C \cdot (V - P)}{P} \cdot ctgX \cdot \frac{1}{T}$$

Note: This formula is simplified and excludes some geometrical details. But under conditions:

- the distance from a camera up to a field of view is more, then 25m;
- the look down angel **X** is from 20 up to 45 degrees;

it works rather precisely.

The Table 2 contains results of calculations of maximal vehicle speed **S** for MegaPixel's systems (Russian license plates - 10 pixels per character) at various values of detection cycle time **T** and look down angel **X**.

Table 2. MegaPixel's systems, maximal vehicle speed **S** (in Km/hour)

X (degree)	**L** (miter)	**T** = 40ms	**T** = 60ms	**T** = 80ms	**T**=100ms	**T**=120ms
20	6.03	543	362	272	217	181
25	4.71	424	283	112	170	141
30	3.80	342	228	171	137	114
35	3.14	282	188	141	113	94
40	2.62	236	157	118	94	79
45	2.20	198	132	99	79	66

Table 3 contains results of calculations of maximal vehicle speed **S** for IMPS system (European license plates - 18 pixels per character) at various values of detection cycle time **T** and look down angel **X**.

Note: the best **T** for IMPS is 400ms. The values 100ms and 200ms are taken from assumption, that the time of detection is less then complete cycle.

Table 3. IMPS system, maximal vehicle speed **S** (in Km/hour)

X (degree)	**L** (miter)	**T** = 100ms	**T** = 200ms	**T** = 400ms
20	3.35	120	60	30
40	1.45	52	26	13

Thus it is possible to assume, that basically IMPS can work with external triggers only (for example, inductive loop sensors).

Camera Installation

The author of Article writes, "The typical look down angle is 40 degrees to avoid blocking the view by the following car". However, it is possible to object, following:

1. The large look down angle does not solve the problem completely.
2. The vertical size of a license plate decreases proportionally **cosX** (**cos40 = 0.77**). Therefore it is necessary to increase the optical resolution. That will result in reduction of a width of a field of view.
3. Not all license plates are fixed strictly vertically (at least in Russia). Some are inclined to horizontal plane. At the large look down angle such plates cannot be read.

Usually in MegaPixel's LPR-systems a lookdown angle from 20 up to 30 degrees are used (but large angles also work). Therefore the system has time to catch same license plate several times. The special algorithm uses it for increase of accuracy of recognition. The accuracy for Russian license plates is from 95% up to 98%.

The Talon system also uses a smaller look-down angle: "Dip: Angle of camera boresight to horizontal should not exceed 20degrees It somewhat limits the system. Besides there are two limitations: "Skew: Angle of camera boresight to vehicle path should not exceed 20 degrees". Rotation: Must not exceed ±2degrees (unless rotation compensation enabled)".

The same parameters for MegaPixel's system are: skew up to 45 degrees, rotation up to ±10 degrees.

There is an exact dependence of a rotation-angle **R** on a dip-angles **X** and a skew-angle **Y**. It is geometrical distortions. But it is not a real rotation; it is a skew in a vertical direction.

Original image

Skew image (20 degree)

The Table 4 contains values a rotation-angle **R** as function from a dip-angles **X** and a skew-angle **Y.**

Table 4. Rotation-angle **R** (degree)

Y / **X**	20	25	30	35	40	45
20	7.1	8.7	10.3	11.8	13.2	14.4
25	9.1	11.2	13.1	15.0	16.7	18.3
30	11.2	13.7	16.1	18.3	20.4	22.2
35	13.5	16.5	19.3	21.9	24.2	26.3
40	16.0	19.5	22.8	25.7	28.3	30.7
45	18.9	22.9	26.6	29.8	32.7	35.3

For a stationary system these angles can be compensated for when the camera is installed. But for mobile systems, the new detection and compensation algorithms are necessary. Recently, MegaPixel developed a special mobile system for police cars in which the camera could rotate around a vertical axis and read license plates as they come in its field of view.

System Integration

MegaPixel has been successful working with system integrators. In Russia the strategic partner of Megapixel is company-integrator JCS Rossi.

For the System Integrator, MegaPixel offers the standard set: the Image Processor MegaFrame-4 board (boards) plus the DLL-software kernel (Borland C++). MegaPixel understands that a system integrator can make system interface better and faster (including use of OCR). MegaPixel stands ready to modify its software and the hardware to meet the business requirements of its customers. MegaPixel also welcomes joint projects.

Summary Characteristics

• Width of a field of view:		
	CarFlow	**3.0m**
	CarFlow II	**5.5m**
• Character's resolution		**10 pixel**
• Zone number		**up to 16**
• Speed of processing:		
	Detection time (CarFlow)	**40ms**
	Detection time (CarFlow II)	**60ms**
	Preprocessing time	**3ms per zone**
	OCR-time	**20ms**
• Speed of a vehicle		**up to 200 Km/hour**
• Camera installation:		
	Dip-angles **X**	**15-45 degree**
	Skew-angle **Y**	**0-45 degree**
	Rotation-angle **R**	**up to ±10 degree**
• Accuracy rate		**95-98%**

Note: all data are given for Russian license plates.

Video Surveillance Motion Detector System MegaSense-8

MegaSense-8 is the MegaPixel's soft/hardware PC-compatible system intended to solve problems of security, supervision, registration and control of access. The system is implemented with the use of the latest neuro-like algorithms of digital image processing and high-speed hardware developed by MegaPixel.

MegaSense-8

Basic functions

1. High-selective detection of movement

- Adaptable to varying lighting conditions which allows it to operate in open space areas;
- High stability to natural (rain, snow, shadows) and artificial (fare light, glare) sources of disturbances;
- Adjustment to objects of specified sizes;
- High rate of control - up to 50 frames per second;
- Zoned masking;
- Three-dimentional supervision.

2. Wide capabilities of registrating videodata:

- storage of frames from any event on any channel;
- storage of frames with a mark of time and date;
- storage of frames with a mark of fault zones.

3. Enhanced means of visualization and processing of videodata:

- scan of recorded frames in playback, rewind, step-by-step, real-time modes;
- enlarging of images with clearness enhancement by using interpolation algorithms;
- scan of recorded frames on a discrete channel;
- storage of individual frames.

4. Wide capabilities of generating spoken messages and controlling external executive devices:

- generation of a spoken message for each event;
- record of spoken messages by the user;
- possibility of remote data access;
- switching on/off remote executive devices (sirens, locks,
- roadway gates, etc.)
- operation in the shade mode without generating of warning signals;
- capability of system enhancement (modem interface with the central control panel, etc.).

System specifications

The system provides the following specifications:

- number of supervision channels - 8;
- resolution on each channel - 384x288 gray or coulor;
- number of control zones for each channel - 16;
- number of generated system alarms - 6 (violation of access rights, disconnection of a camera on each channel, system power cut-off);
- number of user's generated alarms up to 64;
- number of connected external devices up to 64;
- monitoring at close and long distances;
- data processing rate per 8 channel - 3 full cycle per second;
- data processing time per 1 channel -20ms;
- setting of a random mask for each channel and each control zone;
- capability of generating a spoken, text message, image registration and switching on an external device for each event with the use of a priority system;
- JPEG-compression
- switching on external devices for the period of time up to 60 seconds.

The main feature of the system is the use of neuro-like algorithms. The system without regard for changes of average brightness or contrast, it maintains positions of object contours that allows it to avoid false alarms. For example, the system copes with two-multiple jumps of brightness, which can occur at work with luminescent illumination, at the value of a camera shutter - 1/500.

While the MegaSense system was developed as security system, the principles incorporated in it can be used for creation ITS-systems: red-light running, speeding, rail crossing violations, toll violations, antiterror application, incident detection etc.

MegaPixel is committed to assisting it partners and customers adapt this new technology to meet their business needs.

Dr. Michael Routskov, Director of MegaPixel Ltd.

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