Abstract

*We are dealing with the **problem of position estimation of traffic sign** from **single camera** attached to a **vehicle** for which **two mathematical approaches** have been developed. We have created a **synthetic data set**, which enabled us to test the methods in a controlled environment. **Real data set** has been created as a recording in a town. The position can be estimated within the **error of 1 m** in the laboratory conditions. Frequent and accurate GPS sampling is a necessary condition, which has not been fully satisfied in our real data set resulting in an error range starting from **below 1 m up to 4 m on average**. We have also suggested a **potential application** of our approaches for **improving object tracking** in a sense of a **control mechanism**.*

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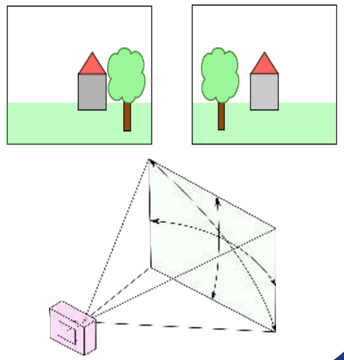
Position estimation of static object from moving camera

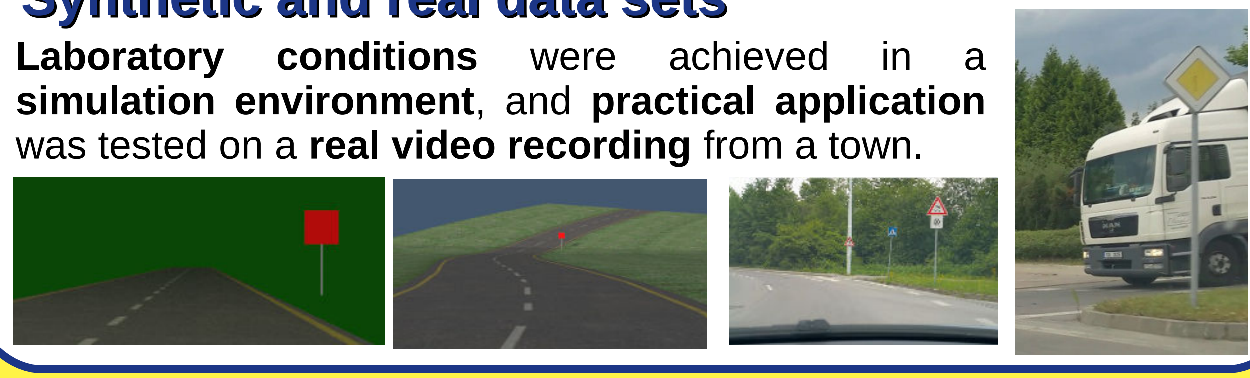
General solution description

The two approaches use **bounding box of the object** of interest and **current position of the camera** in the world to **estimate the object position**. **Two different frames** are always required. Camera calibration is unnecessary, the only needed parameter is the **horizontal angular field of view**.



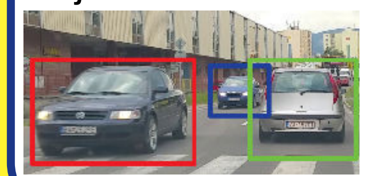
Synthetic and real data sets

Laboratory conditions were achieved in a **simulation environment**, and **practical application** was tested on a **real video recording** from a town.

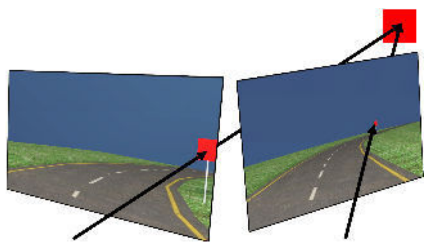


Object tracking

We have **proposed** a way to **utilize our methods** for **improving object tracking** as a **control mechanism** for potentially incorrectly tracked object.



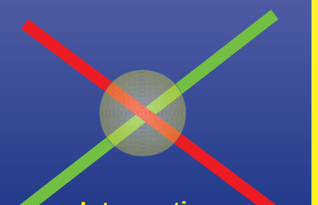
Estimation using intersection of lines



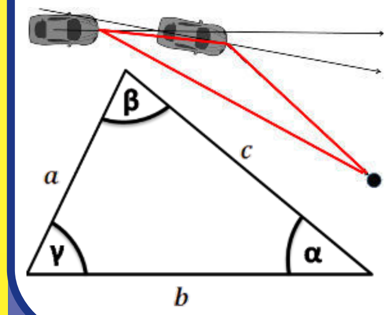
Position is estimated using calculation of **intersection of two lines** in space, in a way similar to **shooting a ray through the optical center of the camera** from two different positions in space.

$$x_t = \frac{y_2 - y_1 + tan\left(p_1\right) x_1 - tan\left(p_2\right) x_2}{tan\left(p_1\right) - tan\left(p_2\right)}$$

$$y_t = tan\left(p_1\right) x_t + y_1 - tan\left(p_1\right) x_1$$



Estimation using triangle properties



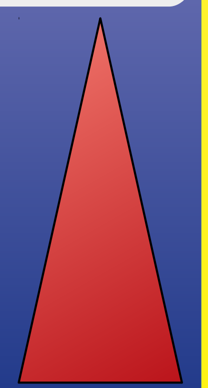
Position is estimated using **properties of the triangle** (fundamentally **law of sines**). Triangle is created from **two different views** of the object with **known distance between positions**.

Object positioning

$$\phi\left(a, b\right) = tan^{-1}\left(\frac{a - b}{1 + ab}\right)$$

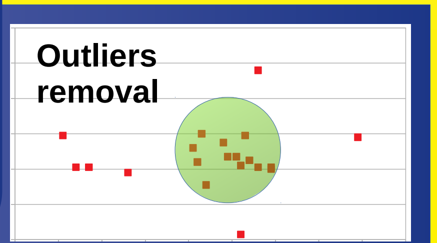
$$x_t = x_1 + sin\left(\pi - \phi\left(m_0, m_2\right)\right)\left(\frac{\sqrt{\left(x_1 - x_2\right)^2 + \left(y_1 - y_2\right)^2}}{sin\left(\phi\left(m_0, m_2\right) - \phi\left(m_0, m_1\right)\right)}\right) cos\left(m_1\right)$$

$$y_t = y_1 + sin\left(\pi - \phi\left(m_0, m_2\right)\right)\left(\frac{\sqrt{\left(x_1 - x_2\right)^2 + \left(y_1 - y_2\right)^2}}{sin\left(\phi\left(m_0, m_2\right) - \phi\left(m_0, m_1\right)\right)}\right) sin\left(m_1\right)$$



Improving of position estimation

Since the two methods operate **only on two frames** there is a potential to use **all the available frame pairs** where the object is visible to **create a final position from elementary ones**. Two approaches were implemented, first **based upon centroid**, the second (more sophisticated) involving **statistical properties of points** in space and principles from **clustering**. The idea is to **remove outliers**.



Experiments and results

We experimented with **various types of scenarios**, different **road curvature** or **elevation**, object **position** or **distance** from camera, etc. Errors ranged from **4 cm** up to **8 m**. Object distance from camera should be below **30 m**.

Conclusion

Solution can be used **when stereo vision cameras are unavailable**. Laboratory error of **below 1 m** shows the potential, while the real world error of **4 m** provides a useful, yet slightly inaccurate **information about object position**.