Development of a Methodology for Estimating the Heat Loss of Buildings based on Neural Networks

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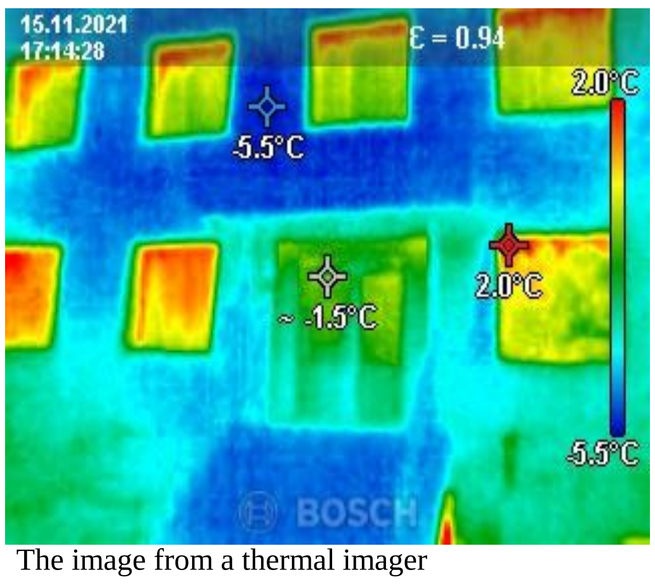
Abstract

The work describes a methodology for estimating the heat loss of a building, including the calculation of the heat loss of a building. In order to develop a methodology for estimating the heat loss of a building based on neural networks, the features of a wooden housing stock were studied. The stage of collecting images for training a neural network, the stage of training an optimal neural network for solving the problem of object detection are described. The technologies necessary to solve the problem are described.

Initial Data

The relevance of the research topic is determined by the lack of a tool for automated estimation of building heat loss. The aim of the work is to increase the reliability of estimating the heat loss of a building from an image from a thermal imager. For achieving this goal, the following tasks were solved:

- the approach for estimating the heat loss of the building was chosen;
- the study of the wooden housing stock of the city of Arkhangelsk was carried out, data were collected for neural network training and software testing;
- software for heat loss estimation was designed;
- software for heat loss estimation was developed;
- the effectiveness of the software was evaluated.



The image from a thermal imager

Name	S	T	k	F
Attic	8 * color_coef	0.2	0.25	Q = S * ($T_в$ – $T_н$) / R * attics_amount
Window	1.5 * color_coef	0.1	0.35	Q = S * ($T_в$ – $T_н$) / R * windows_amount
Chimney	1 * color_coef	0.1	0.52	Q = S * ($T_в$ – $T_н$) / R * chimneys_amount
Entrance door	1.5 * color_coef	0.1	0.3	Q = S * ($T_в$ – $T_н$) / R * doors_amount
Foundation of the house	Home_length * 1 м * color_coef	0.4	0.14	Q = S * ($T_в$ – $T_н$) / R
Roof of the house	Home_length * home_width / 4 * color_coef	0.3	0.2	Q = S * ($T_в$ – $T_н$) / R

Averaged data for estimating heat loss

Methods

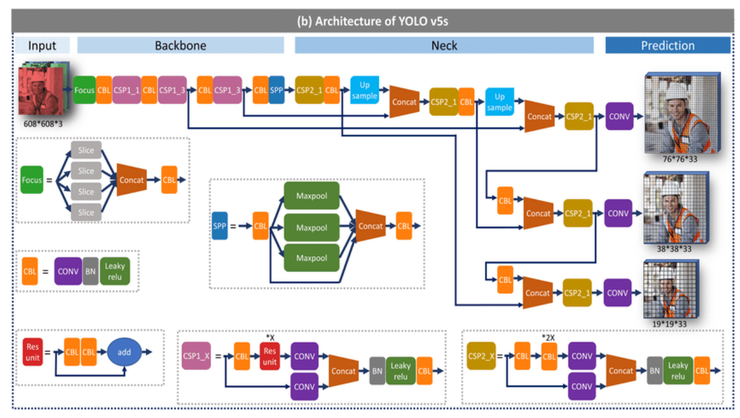
The methodology for estimating heat loss will be as follows:

- The image in the visible spectrum is being corresponded in size to the image in the infrared spectrum.
- The neural network identifies the presence of a structural element and its position in the image in the visible spectrum, limiting it to a frame.
- The average values of the parameters of structural elements (thickness, area, material) are determined.
- The heat loss coefficient is calculated based on the averaged values calculated at the previous stage.
- The calculation of heat losses for each structural element is carried out.

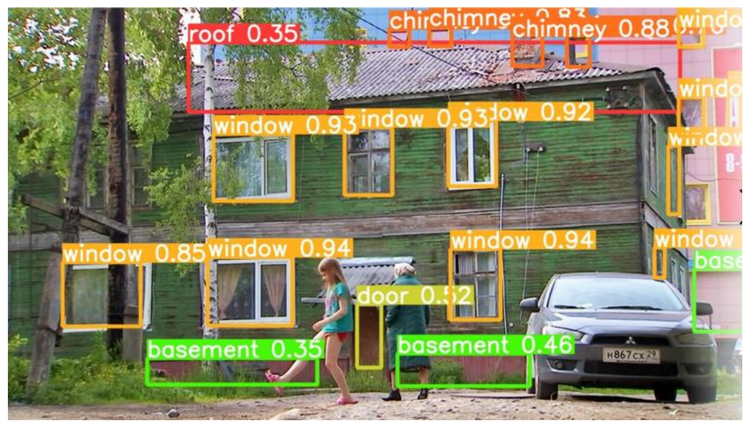
Information about heat loss is applied to a new image.

The algorithm of the function is as follows:

1) the main parameters and variables are set;
2) the image search cycle is started in the working directory in order to open the image being processed;
3) the text file with markup generated by a neural network is opened;
4) for each line of the text file (it means for each object defined by the neural network in the image), the heat loss coefficient is determined;
5) the heat map of the corresponding element is analyzed pixel by pixel, by searching for the most predominant shades. For example, for red color the coefficient of heat loss is “1.0”, for yellow color the coefficient is “0.75”, for green color – “0.5”, blue – “0.3”, and blue – “0.1”;
6) the function of inserting heat loss into the frame with the element is called;
7) total heat losses are calculated;
8) the final result of the software is applied to the image.

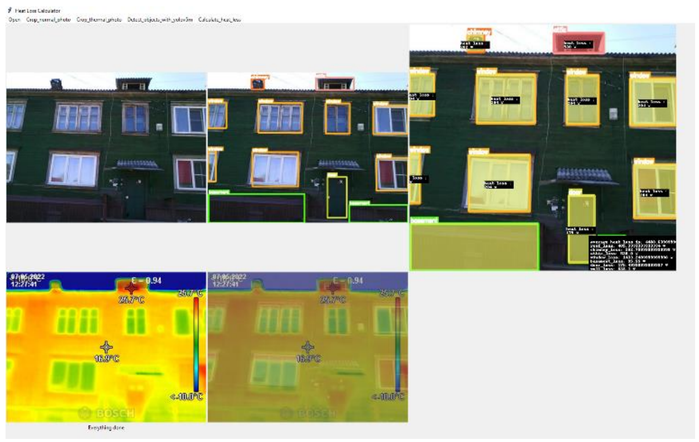


YOLOv5 network architecture



The example of the neural network operation

Results



The program interface

The result of the software operation is images with superimposed colored frames, the color of which depends on the heat loss coefficient, and numerical values of heat losses applied to these frames, as well as in the lower right corner – the total result software operation, generalization of information on the total heat loss of the building on the loaded image.

The following objectives were achieved during the study:

- the approach used to estimate the heat loss of a building was determined;
- the study of wooden housing stock was carried out, the data set was collected for neural network training and software testing;
- software for heat loss assessment was designed and developed;
- the effectiveness of the software was evaluated.

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