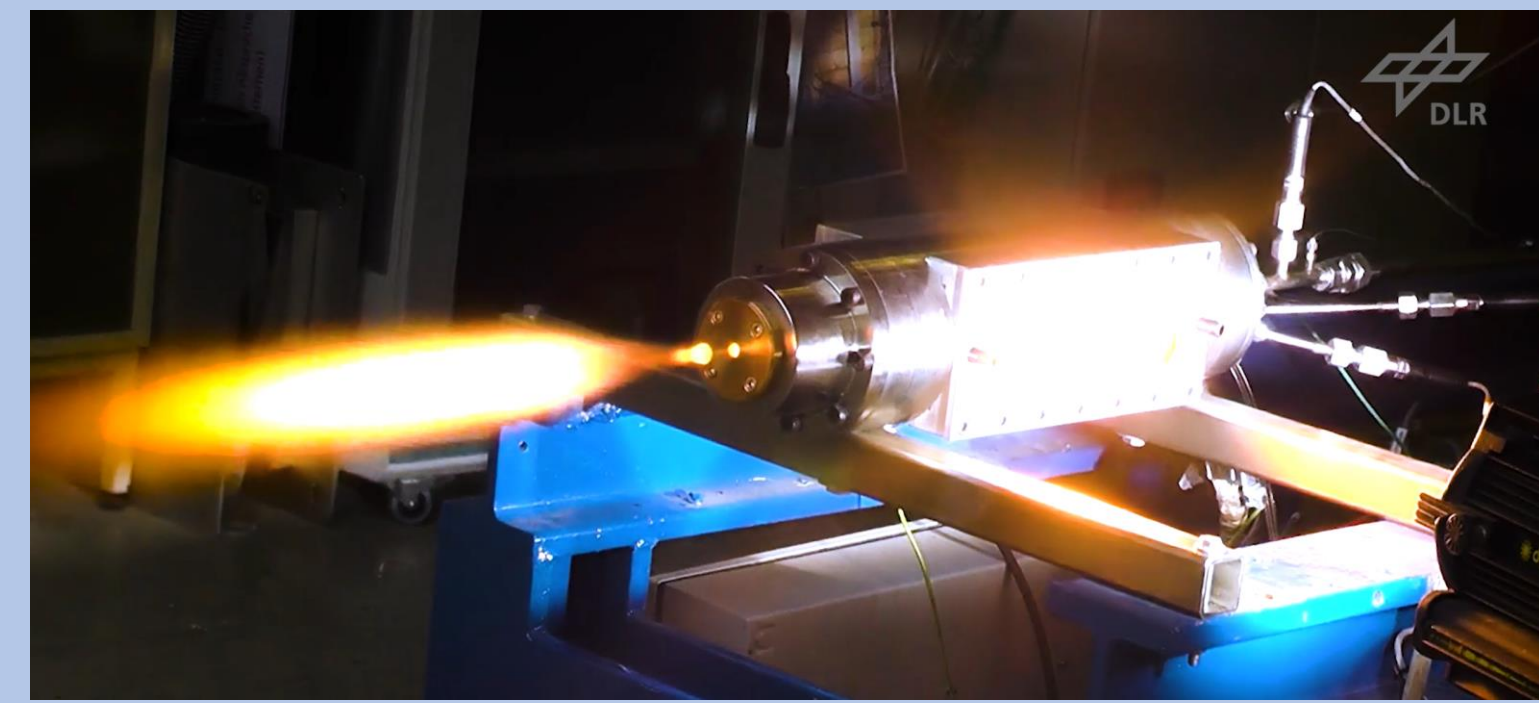


Accurate regression rate determination of hybrid rocket fuels using convolutional neural networks

Combustion tests of hybrid rocket fuels

- Liquid oxidizer is injected into a chamber containing a solid fuel slab
 - In total over 300 tests with varying oxidizer mass flow rates and geometries/compositions of the fuel slab
 - Duration of one experiment is 3 seconds, recorded using a **high-speed camera** at 10 000 frames / second
- **Research question: How do you determine the regression rate from the video?**



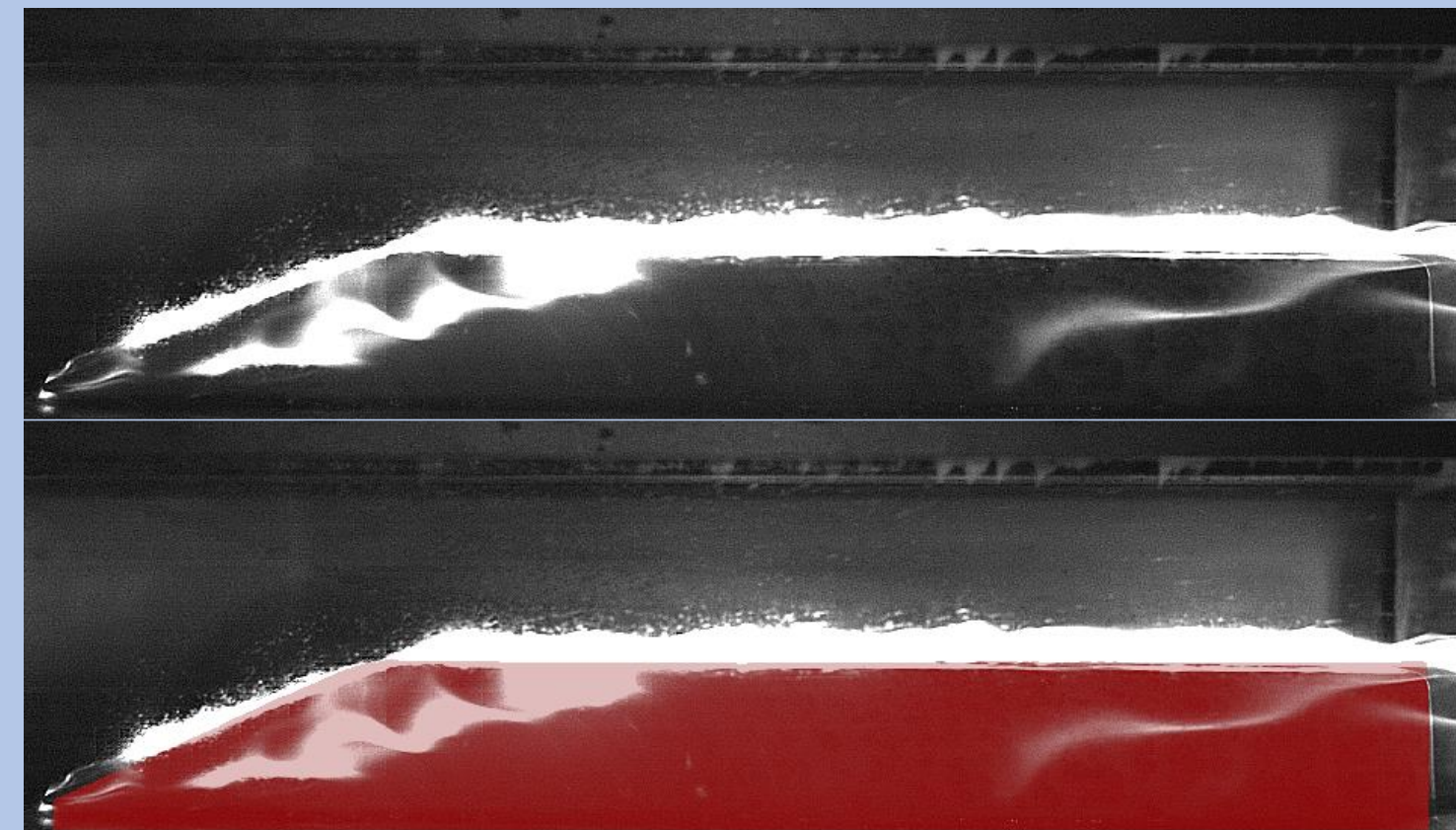
Hybrid rocket fuel combustion chamber



Fuel slab configuration before (top) and after (bottom) combustion test

Current approach

1. Use **Canny filter** to detect the lower edge of the flame
 2. Compute the regression rate as the decrease of this height
- **Very susceptible to noisy data**



Single frame of one combustion test (top) and segmented fuel slab in red (bottom)

ML approach

- Train **convolutional neural network (U-Net)** to segment the fuel slab
- Use slab heights from previous method as training data
- **Strong data augmentation** to improve robustness
- Validate and refine using manually labeled frames

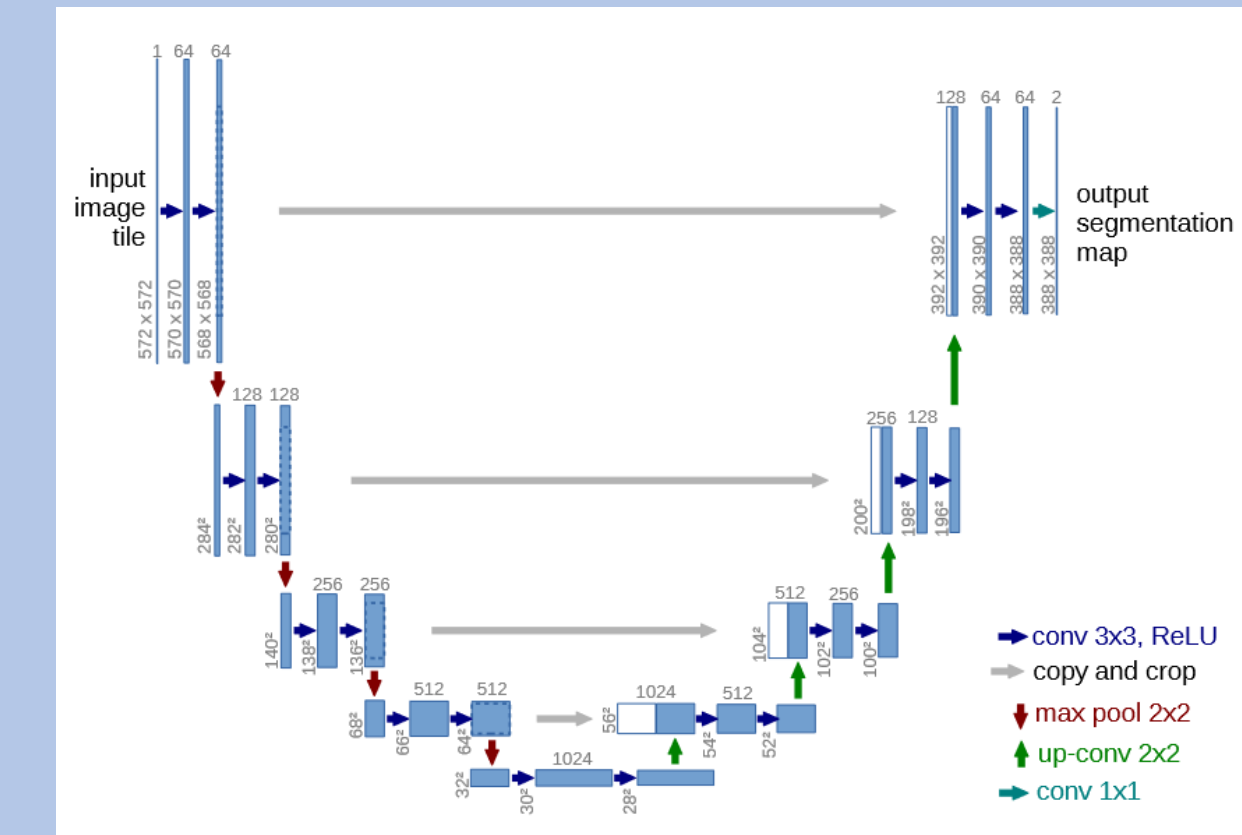
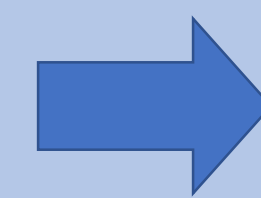
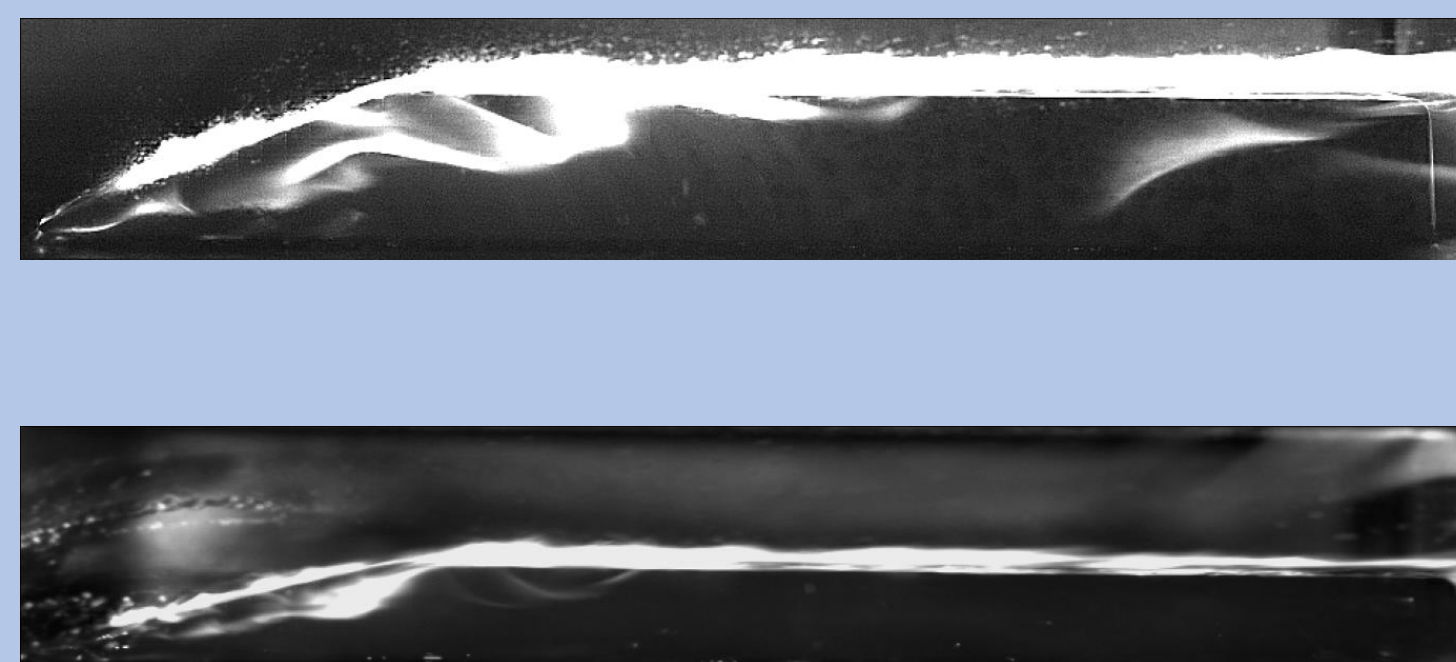
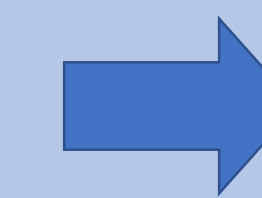
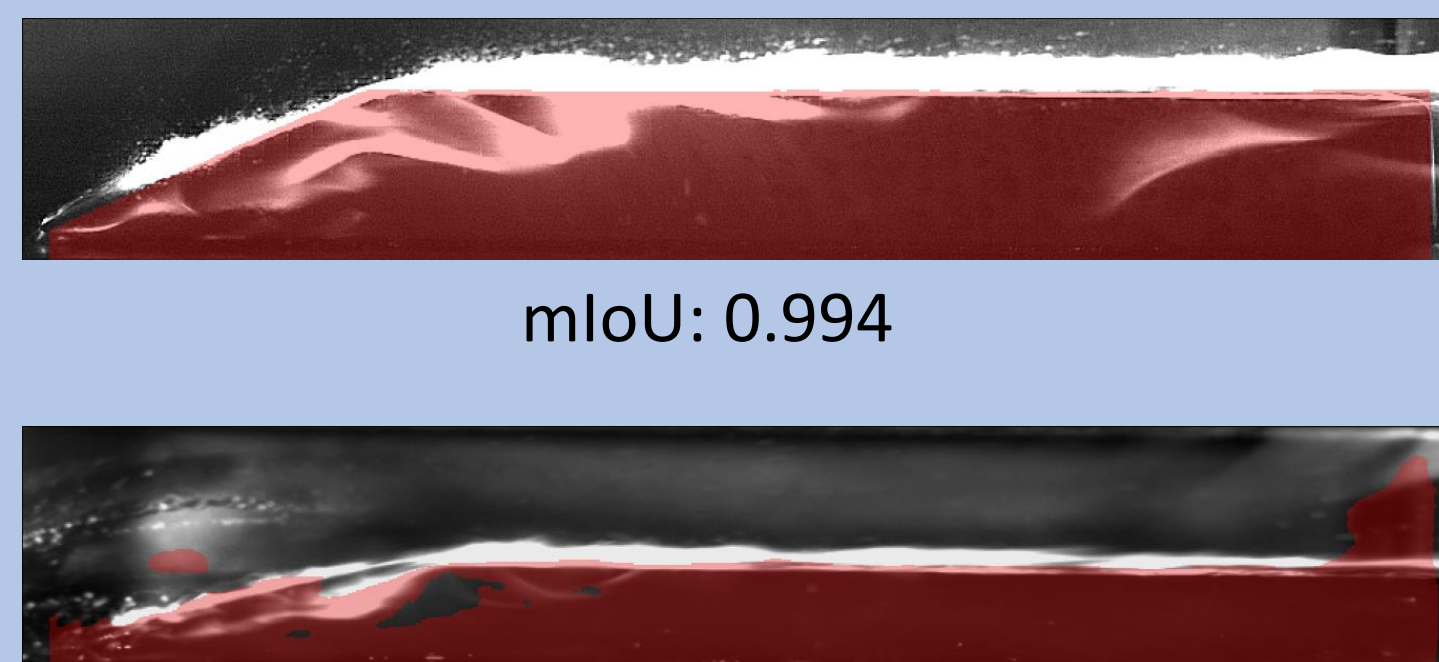


Diagram of U-Net architecture (Ronneberger et al., 2015)

Data from different experiments



Training with weak data augmentation



Training with optimized data augmentation

