Continuous Benchmarking of Protein Structure Predictions

Juergen Haas, ELIXIR-CH

CASP13, 1st December 2018, Playa del Carmen, MX

www.elixir-europe.org
CAMEO is a community project

- CAMEO continuously applies quality assessment criteria established by the protein structure prediction community. Since the accuracy requirements for different scientific applications vary, there is no "one fits all" score. CAMEO therefore offers a variety of scores - assessing different aspects of a prediction (coverage, local accuracy, completeness, etc.) to reflect these requirements.

- CAMEO is a community project - please feel free to suggest additional/alternative ways how CAMEO can support users and developers of structure prediction.

Join CAMEO today...

We invite developers of prediction methods to participate in the continuous evaluation by registering their servers [REGISTER]. We also invite developers of scoring and evaluation methods to suggest alternative scoring schemes. Please contact us directly.

Servers of the following groups are registered so far:

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3D modeling

3D structure models

Evaluation

Target validation scoring

PDB release

PDB pre-release

Target selection submission

Sequences

Day 0

Day 4
Related Complementary Efforts

CAMEO
Weekly Continuous fully Automated Model EvaluatiOn
6’462 targets in 360 weeks
fully automated assessment
https://cameo3d.org

CASP
Community Wide Experiment on the Critical Assessment of Techniques for Protein Structure Prediction
Human expert assessment of ~100 target proteins per 2-year season
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CAPRI
Critical Assessment of PRedicted Interactions
46 CAPRI prediction Rounds were completed with a total of 159 targets
http://www.capri-docking.org

D3R / CELPP
Assessment of protein-ligand interactions / computer-aided drug discovery tools
3 rounds of challenges
https://drugdesigndata.org
CAMEO is Unique

• Continuous: Every Week – Large Number Of Targets, Fast Feed-back.

• Fully Automated: No Human Intervention. Reproducible.

• Open: Modular Platform – Open For New Scores / New Fields.

• Metrics: Scoring Of Different Aspects – No “One Score Fits All”.

• Audience: Method Developers, Peer Reviewers (Papers, Grants).
Unsupervised Evaluation

3D Scoring Must Be Invariant To Domain Movements, i.e. Superposition Independent.

Automatically Evaluate Quaternary Structure, i.e. Stoichiometry And Relative Orientation
Unsupervised Evaluation

Local Distance-difference-test (lDDT)

Fraction Of Correctly Predicted Inter-atomic Distances For Each Atom To Its Neighbors Within Certain Error Thresholds

Mariani, Valerio; et al (2013). lDDT: A local superposition-free score for comparing protein structures and models using distance difference tests. Bioinformatics, 29(21), 2722-2728.

See also: CAD score by C. Venclovas
**Content 3D – 3 Months**

![Target Dataset Composition Table]

**Total Number of Monomeric Models Assessed: 3588**

- Submitted Targets: 248
- With Homo-oligomer Assessment: 107
- Submitted Targets with Ligands: 96

**Based on average IDDT:**
- **Easy** $\geq 75$
- **Medium** $50 < \text{IDDT} < 75$
- **Hard** $< 50$
### Content 3D – 3 Months

#### Target Dataset Composition

<table>
<thead>
<tr>
<th></th>
<th>Any</th>
<th>Easy</th>
<th>Medium</th>
<th>Hard</th>
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<tr>
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<td>248</td>
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<td>126</td>
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<tr>
<td>With Homo-oligomer Assessment</td>
<td>107</td>
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<tr>
<td>Submitted Targets with Ligands</td>
<td>96</td>
<td>16</td>
<td>59</td>
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</tbody>
</table>

Total Number of Monomeric Models Assessed: 3588

Based on average IDDT:  
- **Easy**: \( \geq 75 \)  
- **Medium**: \( 50 < \text{IDDT} < 75 \)  
- **Hard**: \( < 50 \)
CAMEO-3D: All Targets Performance

- Common Subset
  - Disadvantage For Best Server
    - Hard Targets Drop Out
- Binary Comparison Table
- All Scores Per Target

Anonymous Servers are crucial!
Outperformers

Server60 – IDDT: 59.24

HHpred – IDDT: 34.88

2018-11-17_00000062_1 | 6a2j [A]
### 3D Target Distribution – 1 Year

<table>
<thead>
<tr>
<th>Target Dataset Composition</th>
<th>Any</th>
<th>Easy</th>
<th>Medium</th>
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<td>Submitted Targets</td>
<td>998</td>
<td>180</td>
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<tr>
<td>With Homo-oligomer Assessment</td>
<td>381</td>
<td>85</td>
<td>194</td>
<td>102</td>
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<tr>
<td>Submitted Targets with Ligands</td>
<td>393</td>
<td>71</td>
<td>219</td>
<td>103</td>
</tr>
</tbody>
</table>

Total Number of Monomeric Models Assessed: 22598

**Based on average lDDT:**  
**Easy** >= 75  
**Medium** between 50 and 75  
**Hard** < 50
3D Current Efforts – Target Validation 1/2

2018-11-17_0000009_2 (5xLn_B)
3D Current Efforts - Target Validation 2/2

- Rfree < 0.25 / R < 0.3
- R Before/After Refinement < 0.1
- Ramachandran Outliers < 2%
- RSRZ outliers < 20%
- Non-reproducible R factor

6-months < 10
CAMEO goes ELIXIR

OpenEBench: community-driven ELIXIR benchmarking infrastructure

Supporting and interconnecting scientific benchmarking and technical monitoring of bioinformatics tools, web-services and workflows.

• Level 1 – “Share Lead Scores”
  • Contribution to OEB Data Model
  • Provide Weekly data

• Level 2 – “Computing Metrics for Communities – BYO”
  • Prototype Ready with Cancer Genome Atlas (TCGA)

• Level 3 – “Host Benchmarking Efforts for Communities”
  • In Planning - Sustainability And Long-term Commitment
  • CAMEO Being Ported to NextFlow

Capella S, et.al. (2017) bioRxiv 181677
CAMEO-3D – Best Single Template

Target 2018-10-20_00000020_1
(5YLO_B, red)
• Best Server (blue): IDDT 32
• Best Template (green): IDDT 47

Methods: TMALIGN + Modeller
CAMEO CP – New Baselines

- CCMPred (server10)
- EVCouplings (server11)
- PConsC4 (server12)
Summary

• Engaging Community Crucial
  • ELIXIR 3DBioInfo Community
  • CAMEO WorkShop @BC2, Basel 2017
  • Benchmarking Session @ISMB 2018
  • Benchmarking Session @ECCB18

• Weekly Public Data – Ready for Publication
  • Web Aggregators and Download, 360 weeks

• Current CAMEO Efforts around
  • Target Validation + Scoring
  • Modernizing Code Base

Outlook

• Continuously Expose Evaluations to OpenEBench
  • Level 1 – Share Data for Integrated View

• Portable Workflows Employing Containers
  • OpenEBench Level 3 – Executing Workflows

• New CAMEO category
  • Including Ligands
  • Hetero-oligomers

• Add Scores
  • Oligo-IDDT
  • CAD-Score

• Release Regular Benchmarks (DOI) – ModelArchive.org

Acknowledgements

- Dario Behringer, Rafal Gumienny, Xavier Robin, Anna Smolinski, Flavio Ackermann
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- Torsten Schwede
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- CAMEO Participants